@apna_pdf

Objective

PHYSICS

Mechanics

Chapterwise & Subtopicwise

MCQ's

50,000

VOLUME-I

Chief Editor
A.K. Mahajan

These ebooks are free of cost, Join our telegram channel: @apna_pdf

Publisher Declaration
Edited and Published by A.K. Mahajan for YCT Publications Pvt. Ltd.
and printed by R.A. Security Printers In order to Publish the book,
full care has been taken by the Editor and the Publisher,
still your suggestions and queries are welcomed.
In the event of any dispute, the judicial area will be Prayagraj.

₹ : 999/-

Click Here To Join our Telegram Channel
@apna_pdf

CONTENT

- **Units and Measurements** **3-121**
  - Physical Quantities 3
  - Units 7
  - Dimensions of Physical Quantities and Its Applications 15
  - Errors 79
  - Significant Figures 105
  - Measuring Instruments 110
- **Motion in One Dimensions** **122-335**
  - Distance and Displacement 122
  - Speed, Velocity and Acceleration 185
  - Relative Velocity in One Dimension 252
  - Equation of Motion 262
  - Motion Under Gravity 286
  - Motion in Inclined Plane 327
- **Motion in Plane** **336-512**
  - Scalar and Vector Quantities 336
  - Plane Motion Analysis 371
  - Relative Velocity in Plane 377
  - Projectile Motion 392
  - Circular Motion : Uniform Circular Motion, Dynamic Circular Motion 465
- **Laws of Motion** **513-708**
  - Momentum, Force and Inertia 513
  - Newton's Law of Motion and It's Application 526
  - Law of Conservation of Momentum 554
  - Equilibrium of Concurrent Force 586
  - Forces in Mechanism 593
  - Friction, and Inclined Plane Friction Motion 623
  - System of Varying Mass 696
  - Motion of Body Connected Together 700
- **Work, Energy and Power** **709-866**
  - Work done by Force and Power 709
  - Potential and Kinetic Energy 756
  - Conservation of Energy and Work Energy Theorem 807
  - Elastic and Inelastic Collision 823
- **Rotational Motion** **867-1088**
  - Centre of Mass 867
  - Angular Displacement, Velocity and Acceleration 899
  - Torque, Angular Momentum 932
  - Moment of Inertia, Radius of Gyration 973
  - Equilibrium of Rigid Body 1031
  - Rotational Motion and Rotational Energy 1034
  - Rolling Motion 1063

@apna_pdf

01. Unit and Measurement

(a) Physical Quantities

1. The two principal thrusts in physics are
(a) Diversification and complete
(b) Unification and simplification
(c) Unification and reduction
(d) Diversification and simplification

AP EAMCET-08.07.2022, Shift-II

Ans. (c) : The two principal thrusts in physics are Unification and Reduction.

2. Choose the correct statement from following.
(a) Not all basic laws of physics are universal
(b) Conservation laws have a deep connection with symmetries of nature
(c) There are four to six fundamental forces in nature that govern the diverse phenomena of the world
(d) Physics can generate new technology but new physics cannot come out from technology

TS EAMCET 18.07.2022, Shift-I

Ans. (b) : A conservation law is a hypothesis based on observations and experiments.

- Conservation of law is a principle that states that a certain physical property does not change in the course of time within an isolated physical system.
- Conservation laws have a deep connection with symmetries of nature.

3. One angstrom (Å) is equal to:
(a) 10^{-6}mm
(b) 10^{-7}mm
(c) 10^{-8}mm
(d) 10^{-9} mm

AP EAMCET-20.08.2021, Shift-II

Ans. (b) : One angstrom is equal to = 1×10^{-7} mm

$$\because 1\ \overset{o}{A} = 10^{-10}\,m$$
$$= 10^{-10}\,(10^{3})\ mm \qquad \{1\ m = 10^{3}\ mm\}$$
$$= 10^{-7}\ mm$$

4. In which physical quantity, maximum percentage change will be observed, when a copper sphere is heated?
(a) radius
(b) area
(c) volume
(d) length

AP EAMCET-25.09.2020, Shift-I

Ans. (c) : When a copper sphere is heated then maximum percentage change will be observed in its volume.

• Change in Area (A) = $4\pi r^2$

$$\therefore \frac{\Delta A}{A} = 2\left(\frac{\Delta r}{r}\right) = \text{Two times the percentage change}$$

• Change in volume

$$V = \frac{4}{3}\pi r^3$$

$$\therefore \frac{\Delta V}{V} = 3\left(\frac{\Delta r}{r}\right) = 3 \text{ times the percentage change in radius}$$

So, maximum change will occur in volume, when a copper sphere is heated.

5. The angle of 1′ (minute of arc) in radian is nearly equal to
(a) 2.91×10^{-4} rad
(b) 4.85×10^{-4} rad
(c) 4.80×10^{-6} rad
(d) 1.75×10^{-2} rad

[NEET (Oct.) 2020]

Ans. (a) : We know that,

$$1' \text{ (minute of arc)} = \left(\frac{1}{60}\right)^{\circ}$$
$$= \frac{1}{60}\times\frac{\pi}{180} \text{ radian}$$
$$= \frac{\pi}{60\times180}$$
$$= \frac{3.14}{10800}$$
$$= 0.0291\times10^{-2}$$
$$= 2.91\times10^{-4} \text{ radian}$$

6. A dimensionless physical quantity ______
(a) may have a unit
(b) always has a unit
(c) never has a unit
(d) does not exist

AP EAMCET-24.09.2020, Shift-II

Ans. (a) : A dimesnsionless physical quantity may have a unit. It cannot be expressed in term of SI. quantities.
e.g. Radian in the unit for an angle, but it is dimesionless
because it is defined to be the ratio of two lengths.

7. The density of a material in SI units is 128 kg m^{-3}. In certain units in which the unit of length is 25 cm and the unit of mass is 50 g, the numerical value of density of the material is
(a) 40
(b) 16
(c) 640
(d) 410

JEE Main-10.01.2019, Shift-I

Ans. (a) : We know that

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{V} = \frac{M}{L^3}$$

Then, $n_1u_1 = n_2u_2$

$128\,[M_1L_1^{-3}] = n_2\,[M_2L_2^{-3}]$

$$n_2 = \frac{128[M_1L_1^{-3}]}{[M_2L_2^{-3}]}$$

n_1 = numerical value in S.I unit
u_1 = unit in S.I.
n_2 = numerical value in other unit
u_2 = unit in other system

@apna_pdf

In second unit system m = 50g = $\frac{50}{1000}$ kg.

$$L = 25\text{cm} = \frac{25}{100}\text{mtr}$$

$$n_2 = 128\left[\frac{M_1}{M_2}\right]\left[\frac{L_2}{L_1}\right]^3$$

$$= 128 \times \left[\frac{1}{\frac{50}{1000}}\right] \times \left[\frac{\frac{25}{100}}{1}\right]^3$$

$$= 128 \times 20 \times \left(\frac{1}{4}\right)^3$$

$$= 128 \times 20 \times \left(\frac{1}{64}\right)$$

= 40

8. The range of masses we study in Physics is

(a) 10^{-27} to 10^{60} kg
(b) 10^{-27} to 10^{55} kg
(c) 10^{-30} to 10^{55} kg
(d) 10^{-30} to 10^{60} kg

COMEDK 2019

Ans. (c): The electron is considered to be the particle with least mass of 10^{-30} kg. The mass of the known universe is considered to have the highest mass of 10^{55} kg.

9. How many astronomical units are there in 1 metre

(a) 6.68×10^{12} Au
(b) 6.68×10^{-10} Au
(c) 6.68×10^{10} Au
(d) 6.68×10^{-12} Au

SRMJEE-2019

Ans. (d) : 1 Au = 1.496×10^{11} m

$$1\text{ m} = \frac{1}{1.496 \times 10^{11}}\text{ Au}$$

$$1\text{ m} = 6.68 \times 10^{-12}\text{ Au}$$

10. What is dimensions of energy in terms of linear momentum (P), area of (A) and Time (T)

(a) $[P^1A^1T^1]$
(b) $[P^2A^2T^{-1}]$
(c) $[P^1A^{1/2}T^{-1}]$
(d) $[P^{1/2}A^{1/2}T^{-1-}]$

JIPMER-2019

Ans. (c) : Let,

Energy $E = k\,P^a A^b T^c$ ……(i)

Where k is a dimensionless constant of proportionality–

Writing dimension on both sides–

$[ML^2T^{-2}] = [MLT^{-1}]^a[M^0L^2T^0]^b\,[M^0L^0T]^c$

$[ML^2T^{-2}] = [M^aL^{a+2b}T^{-a+c}]$

Comparing the power from both sides–

a = 1 …..(ii)

a+2b = 2 …..(iii)

–a+c= –2 …..(iv)

On solving (ii), (iii) and (iv), we have–

a = 1, b= 1/2, c = –1

So, $[E] = [P^1A^{1/2}\,T^{-1}]$

11. If 10 g cms^{-1} = x Ns. then the number is____

(a) 1×10^{-5}
(b) 1×10^{-4}
(c) 1×10^{-6}
(d) 1×10^{-3}

AP EAMCET-24.04.2018, Shift-II

Ans. (a) : We know that

1g = 10^{-3} kg

1 cm = 10^{-2} m

According to question–

$10\text{ gcms}^{-1} = 10^{-3}\text{ kg} \times 10^{-2}\text{m} \times \text{sec}^{-1}$

$= 10^{-5}\text{kg m.sec}^{-1}$

$= 10^{-5}\text{ Ns} \qquad \left[N = \frac{\text{kgm}}{\text{sec}}\right]$

12. Order of magnitude of a physical quantity is the

(a) Power of 5 of the number that describes the quantity
(b) Power of 10 of the number that describes the quantity
(c) Power of 100 of the number that describes the quantity
(d) Power of 0.01 of the number that describes the quantity

J&K-CET-2018

Ans. (b) : The order of magnitude of a physical quantity is the power of 10 of the number that describes the quantity. It tells us about the largeness or smallness of a physical quantity. It is expressed in the form of a × 10^b where $1 \le a < 10$ and b is a positive or negative integer.

13. A star is very far from earth. If light 10 years from it to reach the earth, calculate the distance between star and earth.

(a) 9.45×10^{16}m
(b) 9.46×10^{-16}m
(c) 9.46×10^{17}m
(d) 9.46×10^{-17}m

SRM JEE-2018

Ans. (a) :

We know that One-light year is the distance Travelled by light in one year.

1 light year = 9.46×10^{12}km = 9.46×10^{15}m

So,

10 light year = $9.4 \times 10^{15} \times 10$ m

= 9.46×10^{16}m

14. It is estimated that cm^2 of earth receives about 2 calorie of heat energy per minute from the sun. This is called solar constant, the value of solar constant in S.I. units is

(a) 2 J m^2s^{-1}
(b) 1.4 Wm^{-2}
(c) 2.4 kWm^{-2}
(d) 1.4 $kJm^{-2}s^{-1}$

AP EAMCET-25.04.2017, Shift-I

Ans. (d) : Given that,

It is estimated that cm^2 of earth receives about 2 calorie of heat energy per minute from the sun.

S = 2 cal/cm^2-min

We know that,

1 cal = 4.18 J

1 cm = 10^{-2} m

1 min = 60 sec

$$\therefore S = \frac{2 \times 4.18}{(10^{-2})^2 \times 60}\ \frac{J}{m^2 - sec}$$

$$S = \frac{2 \times 4.18}{10^{-4} \times 60}$$

@apna_pdf

$$S = \frac{4.18\times10^4}{30}$$

$S = 0.13933 \times 10^4$

$S = 0.14 \times 10^4$

$$S = 1.4\times10^3\ \frac{J}{m^2 - sec}$$

$$S = 1.4\ \frac{kJ}{m^2 - sec}$$

15. A physical quantity of the dimensions of length that can be formed out of C, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]

(a) $\frac{1}{C^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$ (b) $C^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

(c) $\frac{1}{C^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]$ (d) $\frac{1}{C^2}G\frac{e^2}{4\pi\varepsilon_0}$

[NEET 2017]

Ans. (a) : Let,

$$L \propto C^xG^y\left(\frac{e^2}{4\pi\varepsilon_0}\right)^z$$

$$\text{So, } [L] = [C]^x[G]^y\left[\frac{e^2}{4\pi\varepsilon_0}\right]^Z$$

Dimension of [L]= $[M^0L^1T^0]$

Dimension of [C]= $[M^0L^1T^{-1}]$

$$\text{Dimension of } [G] = \left[\frac{Fr^2}{m_1m_2}\right] = \frac{\left[M^1L^1T^{-2}\right][L]^2}{M^2}$$

$=[M^{-1}L^3T^{-2}]$

$$\text{Dimension}\left(\frac{e^2}{4\pi\varepsilon_0}\right) = \frac{(I.T.)^2}{[M^{-1}L^{-3}T^4I^2]} = [M^1L^3T^{-2}I^0]$$

$$[L] = [C]^x[G]^y\left[\frac{e^2}{4\pi\varepsilon_0}\right]^z$$

Putting dimension both sides-

$$[M^0L^1T^0] = [M^0L^1T^{-1}]^x.\ [M^{-1}L^3T^{-2}]^y[M^1L^3T^{-2}]^z$$
$$=[M^0L^xT^{-2x}]\ [M^{-y}L^{3y}T^{-2y}]\ [M^zL^{3z}T^{-2z}]$$
$$=[M^{-y+z}\ L^{x+3y+3z}\ T^{-x-2y-2z}]$$

Comparing the powers from both sides.

$-y+z=0$.....................(i)

$z=y$

$x+3y+3z=1$..............(ii)

$-x-2y-2z=0$............(iii)

Now putting the value of 'z' in eq^n (ii)

$x+3y+3z = 1$

$x+3y+3y = 1$

$x+6y = 1$......................(iv)

Putting the value of z in eq^n..............(iii)

$-x-2y-2z=0$

$-x-2y-2y=0$

$-x-4y=0$

$x=-4y$

Now putting the value of x in eq^n........(iv)

$x + 6y = 1$

$-4y + 6y = 1$

$2y = 1$

$$y = \frac{1}{2}$$

from eq^n (i)

$z = y$

$$\text{So, } z = \frac{1}{2}$$

Now, Putting the value as 'y' in eq^n..(iv)

$x+6y = 1$

$$x + 6\times\frac{1}{2} = 1$$

$x+3 = 1$

$\boxed{x = -2}$

Now, Put the value of x, y, z

$$L = KC^{-2}G^{1/2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^{\frac{1}{2}}$$

$$\text{Then, } L = \frac{1}{C^2}\left(\frac{Ge^2}{4\pi\varepsilon_0}\right)^{1/2}$$

16. In CGS system the magnitude of the force is 100 dynes. In another system, where the fundamental physical quantities are kilogram, metre and minutes. The magnitude of the force is

(a) 0.9 (b) 3.6

(c) 2.7 (d) 1.8

TS EAMCET 28.09.2020, Shift-II

EAMCET-2001

Ans. (b) : Let, $n_1u_1 = n_2u_2$

on writing their dimension both sides-

$n_1\ [M_1L_1T_1^{-1}]$...............(i)

$n_2\ [M_2L_2T_2^{-2}]$...............(ii)

$$\text{Now, } n_2 = n_1\left(\frac{u_1}{u_2}\right)$$

$$n_2 = n_1\left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]\left[\frac{T_1^{-2}}{T_2^{-2}}\right]$$

$$= 100\left[\frac{gm}{kg}\right]\left[\frac{cm}{m}\right]\left[\frac{sec}{min}\right]^{-2}$$

$$= 100\left[\frac{1}{1000}g\right]\left[\frac{1}{100}cm\right]\left[\frac{1}{60}sec\right]^{-2}$$

$$= 100\times\frac{1}{1000}\times\frac{1}{100}\times3600$$

So, $n_2 = 3.6$

@apna_pdf

17. The major contribution of Sir C.V. Raman is
(a) Explanation of photoelectric effect
(b) Principle of buoyancy
(c) Scattering of light by molecules of a medium
(d) Electromagnetic theory

AP EAMCET(Medical)-2014

Ans. (c) : The academy of sciences has resolved to accord the Noble Prize in Physics for 1930 to Sir Chandrasekhara Venkata Raman for his work on the scattering of light and for the discovery of the effect namad after him.

18. Pick out the stranger
(a) Newton-Meter (b) Coulomb-Volt
(c) Coulomb-Farad (d) Watt-Second

SRMJEE - 2014

Ans. (c) : Newton – meter = J
Coulomb – volt = J
Watt – sec = J
and Coulomb – farad ≠ J

19. The prefix atto means
(a) 10^{-21} (b) 10^{-15}
(c) 10^{-18} (d) 10^{-12}

SRMJEE - 2015

Ans. (c) : Atto stands for 10^{-18}.

20. A bus travels at 110 km/hr (kilometers per hour) on open highway. Its speed in meters per second is
(a) 30.6m/s (b) 60.2m/s
(c) 40m/s (d) 50.4m/s

SRMJEE - 2015

Ans. (a) : $S = \frac{110\text{km}}{\text{hr}} = \frac{110\times1000}{60\times60}$

$$= 110\times\frac{5}{18}\ \text{m/s}$$

$$= 30.6\ \text{m/s}$$

21. The prefix giga means
(a) 10^{-9} (b) 10^{9}
(c) 10^{6} (d) 10^{-6}

SRMJEE - 2016

Ans. (b) : Giga stands for 10^{9}.

22. In a new system of units, unit of mass is 10 kg, unit of length is 1 km and unit of time is 1 minute. The value of 1 joule in this new hypothetical system is
(a) 3.6×10^{-4} new units
(b) 6×10^{7} new units
(c) 10^{11} new units
(d) 1.67×10^{4} new units

COMEDK 2016

Ans. (a): Given, M = 10 kg, L = 1 km, T = 1 minute
Now, let n_1 and n_2 are the S.I unit and unit of new system.
Here, $n_1 = 1\text{J}$
The dimensional formula of energy is $[ML^2T^{-2}]$
So, S.I unit of energy = new system

$$n_1\left(\left[M_1L_1^2T_1^{-2}\right]\right) = n_2\left(\left[M_2L_2^2T_2^{-2}\right]\right)$$

$$\frac{n_2}{n_1} = \left(\frac{M_1}{M_2}\right)\left(\frac{L_1}{L_2}\right)^2\left(\frac{T_1^{-2}}{T_2^{-2}}\right)$$

$$\frac{n_2}{n_1} = \left(\frac{1}{10}\right)\times\left(\frac{1}{1000}\right)^2\times\left(\frac{1}{60}\right)^{-2}$$

$$\frac{n_2}{n_1} = 1\times\frac{36}{100000}$$

$n_2 = 1 \times 3.6 \times 10^{-4}$ J
$n_2 = 3.6 \times 10^{-4}$ J

23. Which of the following physical quantity unit is not a fundamental unit?
(a) Length (b) Mass
(c) Magnetic field (d) Current

J&K-CET-2013

Ans. (c) : Magnetic field is not a fundamental unit. Fundamental units are length, mass, time, temperature, amount of substance, current, luminous intensity. These units are used to measure the fundamental quantities.

24. Density of liquid in CGS system is 0.625 g/cm^3. What is its magnitude in SI system?
(a) 0.625 (b) 0.0625
(c) 0.00625 (d) 625

J&K CET- 2005

Ans. (d) : Given that,

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = 0.625\text{g/cm}^3$$

$$= \frac{0.625\times10^{-3}\text{kg}}{10^{-6}\text{m}^3}$$

$= 0.625 \times 10^3$ kg/m^3
$= 625$ kg/m^3

25. The following physical quantities has a ratio of 10^3 between its SI units and CGS units
(a) Universal gravitational constant
(b) Boltzman's constant
(c) Planck's constant
(d) Young's modulus of elasticity

EAMCET-1994

Ans. (a) : Universal gravitational constant

$$\text{SI unit} = \frac{\text{N-m}^2}{\text{kg}^2}$$

$$\text{CGS unit} = \frac{\text{dyne-cm}^2}{\text{gm}^2}$$

$$\text{Ratio} = \frac{\text{SI unit}}{\text{CGS unit}} = \frac{\text{N-m}^2}{\text{kg}^2}\times\frac{\text{gm}^2}{\text{dyne-cm}^2}$$

$$= \frac{\text{N-m}^2}{\text{kg}^2}\times\frac{\left(10^{-3}\text{kg}\right)^2}{10^{-5}\text{N}\times10^{-4}\text{m}^2}$$

$$= \frac{\text{N}-\text{m}^2}{\text{kg}^2}\times\frac{10^{-6}\text{kg}^2}{10^{-9}\text{N}-\text{m}^2}$$

$$= 10^{-6+9}$$

$$= 10^3$$

Hence, the ratio of universal gravitational constant has 10^3 between its SI unit and CGS units.

@apna_pdf

26. In a particular system, the unit of length, mass and time are chosen to be 10 cm, 10 g and 0.1 s respectively. The unit of force in this system will be equivalent to

(a) 0.1 N (b) 1 N
(c) 10 N (d) 100 N

[AIPMT 1994]

Ans. (a) : We know that

$$1N = \frac{1kg \times 1m}{1-s^2}$$

$$= \frac{1000g \times 100cm}{1-s^2}$$

$$= \frac{100 \times (10g) \times 10 \times (10cm)}{100 \times (0.1)^2}$$

So, 1 N = 10 F_{new} (F_{new} is new unit of force)

$$F_{new} = \frac{1}{10} N = 0.1 N$$

27. The value of Planck's constant in SI unit is

(a) 6.63×10^{-31} J-s (b) 6.63×10^{-30} kg-m/s
(c) 6.63×10^{-32} kg-m^2 (d) 6.63×10^{-34} J-s

[AIPMT 2002]

Ans. (d) : Value of Planck's constant in SI unit is 6.63×10^{-34} j-s.
Planck's constant defines the behaviour of particles and waves on atomic scale. S.I. unit of Planck's constant is Joule-second (J.s.).

28. In a new system of units called star units, $1kg^* = 10$ kg, $1m^* = 1$ km and $1s^* = 1$ minute, what will be the value of 1 J in the new system?

(a) $2.4 \times 10^{-5} J^*$ (b) $3.6 \times 10^{-4} J^*$
(c) $4.2 \times 10^{-3} J^*$ (d) $4.2 \times 10^{-2} J^*$

Ans. (b) : 1 kg = 10 kg
∴ [1 kg = 1/10 kg]
1 m = 1 km [∴ 1 m = 1/1000 m]
1 m = 1000 m
1 s = 1 minute
1 sec = 60 sec. [∴ 1 sec = 1/60 sec]
Energy = $[M^1L^2T^{-2}]$
1 Joule = 1 kg × $1m^2$ × $(sec)^2$

$$= \frac{1}{10} kg \times \left(\frac{1}{1000} m\right)^2 \times \left(\frac{1}{60} s\right)^{-2}$$

$$= \frac{1}{10} kg \times (10^{-3})^2 \times \left(\frac{1}{60}\right)^{-2} (s)^{-2}$$

$$= \frac{1}{10} \times 10^{-6} \times (60)^2 \frac{kg(m)^2}{(s)^2}$$

$$\therefore 1 \text{ Joule} = 3.6 \times 10^{-4} \frac{kg(m)^2}{(s)^2}$$

29. A new unit of length is so chosen that the speed of light in vacuum is unity. Calculate the distance (in this new unit) between the sun and the earth if light takes 8 min and 20 seconds to reach earth from sun.

(a) 300 (b) 400
(c) 500 (d) 600

AMU-2012

Ans. (c) : Given that,
The speed of light in a vacuum is unity,
v = 1 m/sec
Time = 8 min and 20 sec = 500 sec
We know that,
Distance = speed × time
Distance = 1 × 500
Distance = 500 unit
Hence, distance between sun and earth is 500 unit.

30. 1 ns is defined as

(a) 10^{-9} s of Kr- clock of 1650763.73 oscillations
(b) 10^{-9} s of Kr- clock of 652189.63 oscillations
(c) 10^{-9} s of Cs- clock of 1650763.73 oscillations
(d) 10^{-9}s of Cs- clock of 9192631770 oscillations

CG PET- 2009

Ans. (d) : 1 ns = 10^{-9} s of Cs-clock of 9192631770 oscillations.

(b) Units

31. The unit of specific resistance is

(a) ohm/m^2 (b) ohm/m^3
(c) ohm m (d) ohm/m

BITSAT-2013, SCRA-1989
MPPET-1984, UPCPMT-1975

Ans. (c) : We know that,

$$R = \rho \frac{l}{A}$$

ρ = specific resistance

$$\rho = \frac{RA}{l}$$

$$\rho = \frac{ohm\text{-}m^2}{m}$$

Unit of ρ = ohm − m

32. The unit of magnetic moment is

(a) A-m^2 (b) A-m
(c) A- m^3 (d) kg-m^2

CG PET- 2006, AMU-2002
MP PET-1996, 1989
MP PMT-2002, 1995

Ans. (a): Magnetic moment is the product of the current flowing and area.
M = I × A
= Ampere-m^2

33. What is the SI unit of Stefan- Boltzmann's constant σ ?

(a) W m^{-2} K^{-4} (b) W m^2 K^4
(c) W K^{-4} (d) erg s^{-2} K^{-4}

COMEDK 2018, Karnataka CET - 2006
AIPMT-2002, MP PET-1992
AFMC-1986, MP PMT-1992, 1989

@apna_pdf

Ans.(a): According to stefan's law, energy per unit time $(E/t) = \sigma A T^4$

$$\sigma = \frac{E/t}{AT^4}$$

$$\sigma = \frac{W}{m^2K^4}$$

$$= Wm^{-2}K^{-4}$$

The SI unit of Stefan's constant = $W.m^{-2}.K^{-4}$ and CGS unit is = $Erg.cm^2$

34. Match List with List II.

List- I		List -II	
(A)	Torque	(I)	Nms^{-1}
(B)	Stress	(II)	$J\ kg^{-1}$
(C)	Latent heat	(III)	Nm
(D)	Power	(IV)	Nm^{-2}

Choose the correct answer from the options given below:

(a) A-III, B-II, C-I, D-IV
(b) A-III, B-IV, C-II, D-I
(c) A-IV, B-I, C-III, D-II
(d) A-II, B-III, C-I, D-IV

JEE Main-29.07.2022, Shift-II

Ans. (b)

(A)	Torque	→	(iii)	Nm
(B)	Stress	→	(iv)	Nm^{-2}
(C)	Latent heat	→	(ii)	$J\ Kg^{-1}$
(D)	Power	→	(i)	Nms^{-1}

35. In SI units, kg m^2 s^{-2} is equivalent to which of the following?

(a) newton (b) watt
(c) joule (d) pascal

AP EAMCET-04.07.2022, Shift-II

Ans. (c) : Given unit is Kg M^2s^{-2}

Dimension of given unit is = $[ML^2T^{-2}]$

Dimension of work (Joule)

= Force × displacement

$= [M^1L^1T^{-2}] \times [L^1]$

$= [ML^2T^{-2}]$

So, the SI unit of Kg m^2s^{-2} is equivalent to Joule.

36. If the unit of length, mass and time each be doubled, the unit of work is increased by

(a) 2 times (b) 4 times
(c) 6 times (d) No change

Assam CEE-31.07.2022

Ans. (a)

Dimension formula of work (W) = ML^2T^{-2}

$$= \left[M\frac{L^2}{T^2}\right]$$

if the unit of L, M, and T are doubled , then the new unit of work

$$= (2M).\frac{(2L)^2}{(2T)^2} = 2\left[M\frac{L^2}{T^2}\right] = 2W$$

∴ The unit becomes two times

37. If E and H represent the intensity of electric field and magnetising field respectively, then the unit of E / H will be

(a) ohm (b) mho
(c) joule (d) newton

JEE Main-27.08.2021, Shift-I

Ans. (a) : The impedance in free space $(z_0) = \frac{E}{H}$

Thus, unit of $\frac{E}{H}$ is ohm.

38. The unit of current element is ________

(a) A m (b) Am^{-1}
(c) Am^2 (d) Am^{-2}

AP EAMCET-06.09.2021, Shift-II

Ans. (a) : The unit of current element is ampere- meter (Am).

39. A force 'F' is given as $F = Pt^{-1} + Qt$, where 't' denotes time. Then, the unit of 'P' must be same as that of _______

(a) Displacement (b) Velocity
(c) Acceleration (d) Momentum

AP EAMCET-06.09.2021, Shift-II

Ans. (d) : Given as $F = Pt^{-1} + Qt$

We know that Dimensional formula of force=$[MLT^{-2}]$

From the principle of dimensional homogeneity

$F = Pt^{-1}$

$[MLT^{-2}] = P\,[T^{-1}]$

So, Dimensional formula of P = $[MLT^{-1}]$

Momentum formula = m×v ⇒ $[MLT^{-1}]$

Hence, the unit of 'P' must be same as that of momentum.

40. If time (t), velocity (v) and angular momentum (l) are taken as the fundamental units, then the dimension of mass (m) in terms of t,v and l is

(a) $[t^{-1}v^1I^{-2}]$ (b) $[t^1v^2I^{-1}]$
(c) $[t^{-2}v^{-1}I^1]$ (d) $[t^{-1}v^{-2}I^1]$

JEE Main-20.07.2021, Shift-II

Ans. (d) : We know,

Dimension of time (t) = [T]

Dimension of velocity (v) = $[LT^{-1}]$

Dimension of angular momentum (I) = $[ML^2T^{-1}]$

So, $m \propto t^a v^b I^c$

$m \propto [T]^a[LT^{-1}]^b[ML^2T^{-1}]^c$

$ML^0T^0 = [M]^c[L]^{b+2c}[T]^{a-b-c}$

So, C = 1, b + 2c = 0. a – b – c = 0

b + 2 = 0 a + 2 – 1 = 0

b = –2 a = –1

So, $\boxed{m \propto [t^{-1}v^{-2}I^1]}$

@apna_pdf

41. Match List-I with List-II

	List-I		List-II
A.	R_H (Rydberg constant)	1.	$\text{kg}\,\text{m}^{-1}\text{s}^{-1}$
B.	h (Planck's constant)	2.	$\text{kg}\,\text{m}^2\text{s}^{-1}$
C.	μ_B (Magnetic field energy density)	3.	m^{-1}
D.	η (Coefficient of viscosity)	4.	$\text{kg}\,\text{m}^{-1}\text{s}^{-2}$

Choose the most appropriate answer from the options given below.

	A	B	C	D
(a)	2	3	4	1
(b)	3	2	4	1
(c)	4	2	1	3
(d)	3	2	1	4

JEE Main-27.08.2021, Shift-II

Ans. (b) : Unit of Rydbery constant (R_H) = m^{-1}
Unit of plank's constant (h) = kg m^2s^{-1}
Unit of magnetic field energy density (μ_B) = kg $m^{-1}s^{-2}$
Unit of coefficient of viscosity = kg$m^{-1}s^{-1}$
So, option (b) is correct.

42. Which of the following is not a unit of time?

(a) Lunar month (b) Light year
(c) Leap year (d) Microsecond

AP EAMCET (23.09.2020) Shift-I

Ans. (b) Lunar month, leap year and microsecond are the units of time but light year is the unit of distance and it is used to measure astronomical distance.

43. The unit of magnetic induction is

(a) Wb m^{-2} (b) Wb m^{-1}
(c) Wb A (d) Wb

AP EAMCET (21.09.2020) Shift-I

Ans. (a) : $\because$ Magnetic Induction $= \dfrac{\text{Magnetic flux}}{\text{Area}}$

$$\therefore \text{The unit of magnetic Inuction} = \frac{\text{Weber}}{\text{meter}^2} = \text{Wb.m}^{-2}$$

44. The SI unit of length is 'meter' suppose we adopt a new unit of length which equals x meter. Then, the area of 1 m^2 expressed in terms of new unit has a magnitude

(a) x (b) x^2
(c) $\dfrac{1}{x}$ (d) $\dfrac{1}{x^2}$

AP EAMCET (21.09.2020) Shift-I

Ans. (d) : Given,
SI unit of length = meter (m)
New unit of length = x meter

And, $1\text{m} = \dfrac{1}{x}$ (New units)

Hence,
Area = 1m^2
$A = 1 \times 1\text{m}^2$

$$= \frac{1}{x}\times\frac{1}{x} = \frac{1}{x^2}$$

45. The S.I unit of inductance is

(a) Kg. m^2. S^{-2}. A^{-2} (b) Kg. S^{-2}. A^{-1}
(c) Kg. m^2. S^{-2}. A^{-1} (d) Kg. m^2. S^{-3}. A^{-2}

TS EAMCET 29.09.2020, Shift-I

Ans. (a): Inductance: -

Electromagnetic or magnetic induction is – the production of an electromotive force across an electrical conductor in a changing magnetic field.

$$v = L \times \left(\frac{di}{dt}\right)$$

L = value of Inductance (H)
i = current
t = time
Henry (H) is - the SI unit of inductance

$$[\text{Volt}] = [L]\left[\frac{\text{Ampere}}{\text{second}}\right]$$

This can be written as–

$$[L] = \left[\frac{\text{Volt} - \text{second}}{\text{ampere}}\right]$$

$$[L] = \left[\frac{\text{Joule}}{\text{Ampere}^2}\right]$$

$$[L] = \left[\frac{\text{kg}\,\text{m}^2\text{S}^{-2}}{\text{A}^2}\right]$$

$$[L] = \text{Kg m}^2\text{S}^{-2}\text{A}^{-2}$$

46. The unit of L/R is (where L= inductance and R = resistance)

(a) sec (b) $\sec^{-1}$
(c) volt (d) ampere

Manipal UGET-2019

Ans. (a) : $$\frac{L}{R} = \frac{\text{Henry}}{\text{ohm}} = \frac{\left(\dfrac{\text{volt}}{A/S}\right)}{\text{ohm}} = \frac{\text{volt.sec}}{\text{ohm.ampere}}$$

$$\frac{L}{R} = \sec$$

• L/R, CR and $\sqrt{LC}$ all have dimensions of Time [T]. So unit will be second.

47. Unit of Magnetic Flux is:

(a) Tesla (b) Gauss
(c) Weber (d) Weber/m^2

AIIMS-26.05.2019(E) Shift-2

Ans. (c) : The SI unit of magnetic flux is weber (Wb). Weber is commonly expressed in a multitude of other units.

$$\text{Wb} = \frac{\text{kg.m}^2}{\text{s}^2.\text{A}} = \text{V.s} = \text{H.A} = \text{T.m}^2 = \frac{\text{J}}{\text{A}} = 10^8\,\text{mx}$$

where,

Wb = Weber	s = second
T = Tesla	H = Henry
V = volt	A = Ampere
J = joule	Mx = Maxwell

@apna_pdf

48. If P, Q and R are physical quantities having different dimensions, which of the following combination can never be a meaningful quantity?

(a) $\frac{P-Q}{R}$ (b) $PQ-R$

(c) $\frac{PQ}{R}$ (d) $\frac{PR-Q^2}{R}$

Karnataka CET-2019

Ans. (a): P , Q and R are physical quantities having different dimensions. By the principle of homogeneity, the physical quantities having different dimensions, can not be added or subtracted directly.

Hence, $\frac{P-Q}{R}$ is not a meaningful quantity.

49. SI unit of inductance is

(a) Ampere (b) Ohm

(c) Henry (d) Faraday

J&K-CET-2019

Ans. (c) : SI unit of inductance is Henry. Inductance is the tendency of an electrical conductor to oppose a change in the electric current flowing through. It is denoted by H.

50. The unit of relative permittivity is

(a) $C^2N^{-1}m^{-2}$ (b) Nm^2C^{-2}

(c) unitless (d) $NC^{-2}m^{-2}$

SRMJEE-2019

Ans. (c) : Relative permittivity $(\varepsilon_r) = \frac{\varepsilon}{\varepsilon_0}$

As it is the ratio of permittivities hence, it has no unit.

51. Which of the following is both unitless and dimensionless?

(a) Angle

(b) Solid angle

(c) Mechanical equilvalent of heat

(d) Refractive index

SRMJEE-2019

Ans. (d) : Refractive index is the property of a material to bend light when passing through one medium to another medium.

The ratio of the speed of light in a vacuum to the speed of light in a medium is called the refractive index of that medium.

$$\text{Reflective index } (\eta) = \frac{\text{Speed of light in vacuum (c)}}{\text{Speed of light in medium (v)}}$$

Since it is the ratio of speed, it has no dimension or units.

52. The C.G.S. unit of magnetic field at a point, due to Biot-Savart law is

(a) Tesla (b) Gauss

(c) Tesla meter/Amp (d) Newton/Amp

J&K-CET-2019

Ans. (b) : The Gauss is the CGS unit for the measurement of magnetic field (B) which is also called the magnetic flux density or the magnetic induction.

1 Gauss = 1×10^{-4} Tesla

The C. G. S. unit of magnetic field at a point is Gauss.

53. In a system, unit of mass is A kg, length is B m and time is C s, then the value of 10 N in this system is

(a) $10\ A^{-1}B^{-1}C^{-2}$ (b) $10\ A^{-1}B^{-1}C^{2}$

(c) $10\ ABC^{-2}$ (d) $5\ A^{-1}BC^{2}$

AP EAMCET (22.04.2018) Shift-II

Ans. (b) : We know that, $N_1u_1 = N_2u_2$

$$10\text{kg}\frac{\text{m}}{\text{s}^2} = N_2\left(\frac{A.B}{C^2}\right)$$

$$\Rightarrow \quad N_2 = \frac{10.C^2}{A.B}$$

$$= 10A^{-1}B^{-1}C^2$$

So, numerical value of 10N in given system is $10A^{-1}B^{-1}C^2$.

54. $\text{kg m}^2\text{s}^{-3}\text{ A}^{-2}$ is the SI unit of

(a) Inductance (b) Resistance

(c) Capacitance (d) Magnetic flux

AP EAMCET-25.04.2018, Shift-I

Ans. (b) : Given that,

$\text{Kg m}^2\text{s}^{-2}$

Dimensional formula of given unit is = $[ML^2T^{-3}A^{-2}]$

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

$$= \frac{[M^1L^2T^{-3}A^{-1}]}{[A]}$$

$$= [M^1L^2T^{-3}A^{-2}]$$

So, the dimensional formula of given unit is equal to the resistance.

55. Dioptre is the unit of

(a) Power of lens (b) focal length

(c) Ionosphere (d) None

HP CET-2018

Ans. (a) : Dioptre is the unit of power of lens and it is reciprocal of focal length.

$$P = \frac{1}{f} \text{ (where f in meters)}$$

56. Which of the following is not the unit of surface tension?

(a) $\frac{N}{m}$ (b) $\frac{J}{m^2}$

(c) $\frac{kg}{s^2}$ (d) $\frac{W}{m}$

UPSEE - 2018

Ans. (d) : The surface tension is a measure of force per unit length.

S.I unit = N/m

or kg/s^2 or J/m^2

Only option (d) $\frac{W}{m}$ is not the unit of surface tension.

57. The unit of Polarizability of the molecule is : _____.

(a) $C^2m^1N^{-1}$ (b) $C^{-2}m^{-1}N^1$

(c) $C^{-2}m^1N^{-1}$ (d) $C^2m^{-1}N^{-1}$

GUJCET 2018

@apna_pdf

Ans. (a) : Formula of Polarizability (α) is

$$\alpha = \frac{P}{E} = \frac{C.m}{N/C}$$

$$\alpha = C^2.m.N^{-1}$$

58. The correct unit of thermal conductivity is

(a) $Jm^{-2}\,sec^{-1}(°C)^{-1}$ (b) $Jm^{-1}\,sec^{-1}(°C)^{-2}$

(c) J-sec (d) $Jm^{-1}\,sec^{-1}(°C)^{-1}$

AIIMS-27.05.2018(E)

Ans. (d): The thermal conductivity of a material is a measure of its ability to conduct heat.

$$\text{Thermal conductivity (K)} = \frac{QL}{A.\Delta T}$$

Where,

Q = Heat transfer through the material
L = Length
A = Area
ΔT = Temperature difference

So,

$$\text{The unit of thermal conductivity} = \frac{Js^{-1} \times m}{m^2 \times °C}$$

$$= Js^{-1}m^{-1}°C^{-1}$$

59. The SI unit of gravitational constant is _____

(a) Nm kg (b) $Nm^2\,kg^{-2}$

(c) Nm^2 kg (d) $N^{-1}\,m^{-2}$ kg

SRMJEEE-2017

Ans. (b) : The SI unit of gravitational constant is Nm^2kg^{-2}

We know that,

$$F = G\frac{m_1m_2}{r^2}$$

The SI unit of

F = N (Newton)
m_1 and m_2 = kg (kilogram)
r = m(meter)

From the above equation, we have

$$G = F.\ \frac{r^2}{m_1m_2}$$

Put the SI units

$$\Rightarrow G = N\frac{(m)^2}{(kg)^2} \Rightarrow G = Nm^2kg^{-2}$$

60. _____ system of units was accepted by the scientist of the general conference on weights and measures.

(a) FPS (b) CGS

(c) MKS (d) SI

SRMJEEE-2017

Ans. (d) : The SI system of unit was accepted by the scientist of the general conference on weights and measure in 1971. In 1960 the 11th CGPM approved the International system of units, usually known as "SI".

61. The SI unit of mechanical equivalent of heat is

(a) J/cal (b) J-cal

(c) cal. erg (d) erg/J

CG PET- 2017

Ans. (a) : Mechanical equivalent of heat, if the work is completely changed to the heat energy, then the some amount of heat is generated. Mathematically,

$$J = \frac{W}{q}$$

Here, W = Amount of work required to generate heat
q = Amount of heat

$$= \frac{\text{Joule}}{\text{Calorie}}$$

So, SI unit of mechanical equivalent of heat is J/cal.

62. Siemen is the SI unit for

(a) electrical resistivity
(b) electrical conductance
(c) electrical permittivity
(d) electrical capacitance

EAMCET-1992

Ans. (b) : Conductance is defined as

$$\text{Conductance} = \frac{1}{\text{Resistance}}$$

$$= \frac{1}{\text{ohm}}$$

$= (\Omega)^{-1}$ or siemen

Hence siemen is the SI unit for electrical conductance.

63. The SI unit of moment of inertia is

(a) kgm^{-2} (b) kg m^2

(c) Nm^{-2} (d) Nm^2

EAMCET-1999

Ans. (b) : The moment of Inertia ($I=MR^2$) is specified based on the distribution of mass in the body with respect to axis of rotation.

SI unit moment of Inertia is kg.m^2.

64. If $x = at + bt^2$, where x is the distance travelled by the body in kilometer while t is the time in second, then the unit of b is

(a) km/s (b) km-s

(c) km/s^2 (d) km-s^2

[AIPMT 1989]

Ans. (c) : Given that,

$x = at + bt^2$ (where x is distance)

From principle of Homogeneity

$[x] = [at] = [bt^2]$

$[L] = b[T^2] \Rightarrow b = [LT^{-2}]$

So, Unit of b = km/s^2

65. The unit of permittivity of free space, ε_0 is

(a) coulomb/newton-metre
(b) newton-metre^2/coulomb^2
(c) coulomb^2/newton-metre^2
(d) coulomb^2/(newton-metre)^2

AIPMT 2004
Karnataka CET-2004

Ans. (c) : Coulomb law state that.

$$F = \frac{1}{4\pi\varepsilon_0}.\frac{q_1.q_2}{r^2}$$

$$\varepsilon_0 = \frac{q_1.q_2}{4\pi F.r^2}$$

@apna_pdf

When, unit of F = N

Unit of r = m

Unit of q = Coulomb (c)

$$\varepsilon_0 = \frac{\text{Coulomb}\times\text{Coulomb}}{\text{newton}-(\text{metre})^2}$$

$$\varepsilon_0 = \frac{\text{C.C}}{\text{N.m}^2} = \text{Coulomb}^2/\text{newton}-\text{metre}^2$$

66. The equation $\left(p+\frac{a}{V^2}\right)(V-b)$ = constant. The units of a is

(a) Dyne × cm^5 (b) Dyne × cm^4

(c) Dyne/cm^3 (d) Dyne/cm^2

UP CPMT-2014

Ans. (b) : Given that,

$$\left(P+\frac{a}{V^2}\right)(V-b) = \text{constant}$$

In the term $\left(P+\frac{a}{V^2}\right)$, the units of p and $\frac{a}{V^2}$ are the same

$\therefore$ $a = PV^2$ [here v is the volume]

$\therefore$ Unit of a = unit of P × unit of v^2

$$\therefore \text{ Unit of a} = \frac{\text{dyne}}{\text{cm}^2}\times(\text{cm}^3)^2$$

$$= \frac{\text{dyne}}{\text{cm}^2}\times\text{cm}^6$$

$$= \text{dyne}\times\text{cm}^4$$

Note:– Here we use CGS system. In SI system unit of a is N-m^4

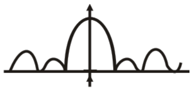
67. SI unit of intensity of wave is

(a) $J\,m^{-2}s^{-1}$ (b) $J\,m^{-1}s^{-2}$

(c) $W\,m^{-2}$ (d) $J\,m^{-2}$

UP CPMT-2012

Ans. (a,c) : The intensity of waves is defined as the power delivered per Unit area.



center of pattern

$$\text{Intensity of wave} = \frac{\text{energy}}{\text{Area}\times\text{Time}}$$

$$= \frac{J}{m^2\times S} = Wm^{-2}$$

$\therefore$ The S.I Unit of intensity of wave is Wm^{-2}.

68. Unit of electrical conductivity is

(a) ohm (b) siemen

(c) m/mho (d) mho/m

UP CPMT-2010

Ans. (d) : Resistivity and conductivity are interrelated Conductivity is the inverse of resistivity. According to this is easy to express one in terms of the other.

$$\sigma = \frac{1}{\rho} \text{ unit mho/m or siemen/m}$$

69. The Bernoulli's equation may be written as: $P+\frac{1}{2}\rho v^2 + h\rho g = K$ (a constant). The unit of K/P is same as that of:

(a) pressure (b) thrust

(c) angle (d) none of the above

SRMJEE - 2011

Ans. (d) : In the given equation

$$[K] = [P]$$

$$\Rightarrow \left[\frac{K}{P}\right] = \left[M^0L^0T^0\right]$$

$\Rightarrow$ Dimensionless and has no units.

70. The velocity of a particle depends upon t as v = A + Bt + Ct^2. If velocity is in m/s, the unit of A will be

(a) m/s (b) m/s^2

(c) ms (d) m^2/s

SRMJEE - 2012

Ans. (a) : Given that, $v = A + Bt + Ct^2$

According to principle of homogeneity

Unit of A = unit of Bt = unit of Ct^2 = unit of V

Unit of A = unit of V

Unit of A = m/s

71. Which one of the following physical quantities does not have unit?

(a) luminous intensity (b) momentum

(c) current (d) refractive index

SRMJEE - 2015

Ans. (d) : Refractive index of medium = $\frac{c}{v}$

72. Which of the following pairs of physical quantities may be represented in the same unit?

(a) Heat and temperature

(b) Temperature and mole

(c) Heat and work

(d) Specific heat and heat

MP PET-2012

Ans. (c) : The unit of heat is Joule.

The unit of temperature is Kelvin.

The unit of work is Joule.

The unit of specific heat is Joule/gram degree Celsius.

- The same unit is represented heat and work.

73. If mass is measure in units of α kg, length in β m and time in γ sec then calorie would be

(a) $4.2\,\alpha\,\beta^2\gamma^{-2}$ (b) $4.2\,\alpha^{-1}\beta^2\gamma^2$

(c) $4.2\,\alpha^{-1}\beta^{-2}\gamma^2$ (d) $4.2\,\alpha^{-2}\beta^{-1}\gamma^{-2}$

AMU-2012

Ans. (a) : Given data,

Unit of mass = α = [M]

Unit of length = β = [L]

Unit of time = γ = [T]

Unit of work = Joule

@apna_pdf

We know that,

Let $[ML^2T^{-2}] = \alpha^x \beta^y \gamma^z$

Both side comparing

$X = 1, y = 2, z = -2$

Dimension of work $= [ML^2T^{-2}] = \alpha \beta^2 \gamma^{-2}$

As 1 cal = 4.2 Joule

$\Rightarrow$ Calorie = 4.2 Joule

$$= 4.2 \left(\alpha \beta^2 \gamma^{-2}\right)$$

$\Rightarrow$ Unit of Calorie $= 4.2 \left(\alpha \beta^2 \gamma^{-2}\right)$

74. Unit of surface tension in S.I system is

(a) N-m (b) $N\text{-}m^{-1}$

(c) $N\text{-}m^2$ (d) $N\text{-}m^{-2}$

CG PET- 2013

Ans. (b) : As we know,

$$\text{Surface tension } = \frac{\text{Force}}{\text{Length}} = \frac{F}{L}$$

Unit of surface tension in :

- In S.I system = N/m
- In CGS system = Dyne/cm
- In MKS system = kgf/m

75. The velocity of a particle is given by $v = at^2 + bt + c$ If v is measured in ms^{-1} and t is measured in second, the unit of

(a) a is ms^{-1}

(b) b is ms^{-1}

(c) c is ms^{-1}

(d) a and b is same but that of c is different

CG PET- 2010

Ans. (c) : Given,

$v = at^2 + bt + c$, $v = ms^{-1}$ and t = second

Then,

Unit of v = Unit of at^2

$V = at^2$

$$a = \frac{v}{t^2} = \frac{ms^{-1}}{\text{Second}^2} = ms^{-3}$$

Unit of v = Unit of bt

$v = bt$

$$b = \frac{v}{t} = \frac{ms^{-1}}{\text{Second}} = ms^{-2}$$

Unit of v = Unit of c

$c = v = ms^{-1}$

76. In SI system the unit of dipole moment is

(a) C-m (b) $C\text{-}m^2$

(c) C/m^2 (d) C/m

CG PET- 2006

Ans. (a) : Dipole moment – The dipole moment is defined as the product of the magnitude of one of the charge of the dipole and the separation distance between them.

Dipole moment $|\vec{P}| = q \times 2a$

Where, q = magnitude of either charge of dipole

2a = separation distance

Thus, SI unit of dipole moment is C-m.

77. The unit of inductance is equal to

(a) $\frac{\text{Volt} - \text{sec}}{\text{Amp}}$ (b) $\frac{\text{Volt} \times \text{Amp}}{\text{sec}}$

(c) $\frac{\text{Volt} \times \text{sec}}{\text{Volt}}$ (d) $\frac{\text{Volt}}{\text{Amp} \times \text{sec}}$

CG PET- 2004

Ans. (a) : The unit of inductance is Henry (H) which is expressed as the amount of inductance that causes a voltage of one volt, when the current is changing at a rate of one ampere per second.

The induced voltage from electromotive force can be expressed as –

$$e = L\frac{dI}{dt}$$

The above equation can be written using corresponding SI units as

$$\text{Volt} = [L]\left[\frac{\text{Ampere}}{\text{Second}}\right]$$

This can be written as

$$L = \frac{\text{Volt} - \text{sec}}{\text{Ampere}}$$

78. Young's modulus of a material has the same units as

(a) pressure (b) strain

(c) compressibility (d) force

CG PET- 2004

Ans. (a) : We know that,

$$\text{The young's modulus is } (Y) = \frac{\text{Stress}}{\text{Strain}}$$

$$Y = \frac{F/A}{\Delta l/l} \qquad [\because \text{ Strain is dimensionless}]$$

$Y = N/m^2$, which is equal to unit of pressure.

79. Which of the following quantities has a unit but dimensionless?

(a) Strain

(b) Reynold's number

(c) Angular displacement

(d) Poisson's ratio

BITSAT-2005

Ans. (c) : Among the given quantities, the angular displacement has unit (degree or radian) but it is dimensionless.

80. Which of the following is the smallest unit?

(a) Millimetre (b) Angstrom

(c) Fermi (d) Metre

UPSEE - 2010

Ans. (c) : 1 Fermi $= 10^{-15}$ m

1 Angstrom (Å) $= 10^{-10}$ m

1 millimeter $= 10^{-3}$ m

meter is the unit of length

So, the smallest unit is Fermi.

@apna_pdf

81. Given that : $y = A\sin\left[\left(\frac{2\pi}{\lambda}\right)(ct - x)\right]$ where, y and x are measured in metres. Which of the following statements is true?

(a) The unit of λ is same as that of x and A
(b) The unit of λ is same as that of x but not of A
(c) The unit of c is same as that of $\frac{2\pi}{\lambda}$
(d) The unit of (ct –x) is same as that of $\frac{2\pi}{\lambda}$

UPSEE - 2006

Ans.(a) : Here, $\frac{2\pi}{\lambda}(ct - x)$ is dimensionless.

Hence, $\frac{ct}{\lambda}$ is also dimensionless and unit of ct is same as that of x.

Therefore, unit of λ is same as that of x. Also limit of y is same as that of A, which is also same as unit of x.

82. SI unit of coefficient of viscosity is

(a) Nsm^{-2} (b) $Ns^{-1}m^2$
(c) Nsm^{-3} (d) $Ns^{-2}m$

JCECE-2018
J.K. CET - 2004

Ans. (a) : The Co-efficient of viscosity η is defined as the tangential force F required to maintain a unit velocity gradient between two parallel layer of liquid of unit area A.

Co-efficient of viscosity $(\eta) = \frac{Fr}{AV}$

Where, F = Force
A = Area
V = Velocity
r = Distance between the layers

$$\eta = \frac{N\text{-}m}{m^2 \times m/sec} = Nsm^{-2}$$

83. Which is not the unit of electric field?

(a) $\frac{N}{C}$ (b) $\frac{N-m}{C}$
(c) $\frac{V}{m}$ (d) $\frac{J}{C-m}$

JCECE-2006

Ans. (b) :

$\because$ Electric field $(E) = \frac{Force}{Charge}$ = N/coloumb or N/C

$\because$ The relation between an electric field and an electric potential is

E = Potential (v) / distance (r)

$$\text{unit of E.F.} = \frac{v}{m}$$

Also,

$$E = \frac{W}{q.x} = \frac{J}{C-m}$$

84. If the capacitance of a nanocapacitor is measured in terms of a unit 'u' made by combining the electric charge 'e', Bohr radius 'a_0', Planck's constant 'h' and speed of light 'c' then

(a) $u = \frac{e^2h}{a_0}$ (b) $u = \frac{hc}{e^2a_0}$
(c) $u = \frac{e^2c}{ha_0}$ (d) $u = \frac{e^2a_0}{hc}$

AIIMS-2016

Ans. (d) : Let 'u' related with e, a_0, h and c as

$$[u] = [e]^a [a_0]^b [h]^c [c]^d \quad .....(i)$$

Using dimension formula,

$$[M^{-1}L^{-2}T^4A^2] = [A^1T^1]^a [L]^b [ML^2T^{-1}]^c [LT^{-1}]^d$$

$$[M^{-1}L^{-2}T^4A^2] = [M^cL^{b+2c+d}T^{a-c-d}A^a]$$

Comparing power

a = 2, c = –1,

a – c – d = 4

d = – 4 + 3 = –1

Putting the value of d,

b + 2c + d = –2

b = 1

Hence, a = 2, b = 1, c = –1, d = –1

Putting the value of a, b, c, d in equation (i)

$u = e^2 a_0^1 h^{-1}c^{-1}$

$$\therefore \quad u = \frac{e^2a_0}{hc}$$

85. If e is the charge, V the potential difference, T the temperature, then the units of $\frac{eV}{T}$ are the same as that of

(a) Planck's constant
(b) Stefan's constant
(c) Boltzmann's constant
(d) Gravitational constant

AIIMS-2016

Ans. (c) :

$$\because \frac{eV}{T} = \frac{\text{Work done}(W)}{T}$$

$$= \frac{PV}{T} \qquad \left(\because PV = \frac{RT}{N}\right)$$

$$= \frac{R}{N} = K = \text{Boltzmann constant}$$

86. "Parsec" is the unit of:

(a) time (b) distance
(c) frequency (d) angular acceleration

AIIMS-2005

Ans. (b) : Parsec is an astronomical unit of length equal to the distance at which a baseline of one astronomical unit subtends an angle of one second of arc.

1 Parsec = 3.08 × 10^{16} m
= 3.26 light year

@apna_pdf

87. Which one of the following is not a unit of Young's modulus ?

(a) Nm^{-1} (b) Nm^{-2}

(c) dyne cm^{-2} (d) mega pascal

Karnataka CET-2005

Ans. (a) : Nm^{-1} is not a unit of Young's modulus'.

$$\text{Young's modulus (y)} = \frac{\text{Stress}}{\text{Strain}} = \frac{N}{m^2}$$

CGS unit of young modulus is dyne cm^{-2} and represents the units of young's modulus in Nm^{-2} and Mega Pascal.

88. Which one of the following units is not that of mutual inductance?

(a) henry (b) weber

(c) ohm second (d) volt second $(\text{ampere})^{-1}$

J&K CET- 2010

Ans. (b) : Henry, ohm second, volt second $(\text{ampere})^{-1}$ are units of mutual inductance, Weber is the unit of magnetic flux.

89. The SI unit of electron mobility is

(a)$m^2\ s^{-1}\ V^{-1}$ (b) $m\ s\ V^{-1}$

(c)$m\ s^{-1}\ V$ (d) $m^2\ s^{-2}\ V^{-2}$

J&K CET- 2009

Ans. (a) : The SI unit of electron mobility is $m^2\ s^{-1}\ V^{-1}$

$$\text{Electron mobility } (\mu) = \frac{\text{Drift veloity}}{\text{Electric field}} = \frac{V_d}{E}$$

$$\mu = \frac{V_d}{E} = \frac{ms^{-1}}{Vm^{-1}} = m^2s^{-1}V^{-1}$$

90. The Poiseuille is the unit of

(a) pressure (b) friction

(c) surface tension (d) viscosity

J&K CET- 2002

Ans. (d) : The Posieuille is the unit of viscosity. Viscosity is a measure of fluid's resistance to flow.

SI unit of viscosity is pascal second or $kg.m^{-1}$, s^{-1}

91. Which of the following is not a unit of energy?

(a) Ws (b) $kg\ m\ s^{-1}$

(c) N m (d) $kg\ m^2\ s^{-2}$

J&K CET- 1997

Ans. (b) : Energy = Force × distance

$$= N - m = kg.\frac{m}{s^2}.m$$

$$= \frac{kg.m^2}{s^2} = \frac{J.s}{s} = W.s$$

Energy = N.m , W.s, $Kg.m^2.s^{-2}$

Hence, $kg.m.s^{-1}$ is not a unit of energy.

92. The unit of molar gas constant is

(a) $J\ K^{-1}\ mol^{-1}$ (b) J

(c) J K (d) $J\ mol^{-1}$

J&K CET- 2000

Ans. (a) : Molar gas constant is a fundamental physical constant which in denoted by the symbol R.

The SI unit of the molar gas constant is Joule per Kelvin per mole ($JK^{-1}\ mol^{-1}$).

93. What is the unit of magnetic permeability?

(a) $Wb\ A^{-1}\ m^{-1}$ (b) Wb^{-1} Am

(c) $Wb\ A\ m^{-1}$ (d) $Wb\ A^{-1}$ m

BITSAT-2008

Ans. (a) : The SI unit of magnetic permeability is

$$B = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

$$\mu_0 = \frac{B(4\pi)r^2}{Idl\sin\theta} = \frac{Wb}{m^2}\times\frac{m^2}{A\times m}$$

$$\mu_0 = WbA^{-1}m^{-1}$$

94. Electron-volt is the unit of-

(a) Charge (b) Potential

(c) Momentum (d) Energy

CG PET-22.05.2022, 2006

Ans. (d) : Electron-Volt is the unit of 'energy.

95. The S. I. unit of thermal conductivity is

(a)$J\ S\ m^{-1}\ K^{-1}$ (b) $W^{-1}\ m^{-1}\ K^{-1}$

(c)$W\ m^{-1}\ K^{-1}$ (d) $W\ m^{-2}\ K^{-1}$

J&K CET- 2011

NEET (National) 2019

Ans. (c) : The unit of thermal conductivity $(k) = \frac{QL}{A\Delta T}$

$$\text{Unit of } k = \frac{M}{M^2\times K}\times\text{watt}$$

$$k = Wm^{-1}K^{-1}$$

(c) Dimensions of Physical Quantity and Its Applications

96. The equation of a circle is given by $x^2 + y^2 = a^2$, where a is the radius. If the equation is modified to change the origin other then (0, 0), then find out the correct dimensions of A and B in a new equation :

$(x - At)^2 + \left(y - \frac{t}{B}\right)^2 = a^2$. The dimensions of t is given as $[T^{-1}]$.

(a) $A = [LT], B = [L^{-1}T^{-1}]$

(b) $A = [L^{-1}T], B = [LT^{-1}]$

(c) $A = [L^{-1}T^{-1}], B = [LT]$

(d) $A = [L^{-1}T^{-1}], B = [LT^{-1}]$

JEE Main-29.01.2023, Shift-II

Ans. (a) : According to principle of dimensional homogeneity

$$x - At = 0$$

$$[x] = [A]\,[t]$$

$$[L] = [A]\,[T^{-1}]$$

$$[A] = [LT]$$

$$y - \frac{t}{B} = 0 \qquad [y] = \frac{[t]}{[B]},$$

$$[B] = \frac{[t]}{[y]} = \left\lfloor L^{-1}T^{-1}\right\rfloor$$

@apna_pdf

97. $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ **represents the equation of state of some gases. Where P is the pressure, V is the volume, T is the temperature and a, b, R are the constants. The physical quantity, which has dimensional formula as that of** $\frac{b^2}{a}$**,will be**

(a) Bulk modulus (b) Compressibility
(c) Modulus of rigidity (d) Energy density

JEE Main-01.02.2023, Shift-I

Ans. (b) : $\left(P+\frac{a}{V^2}\right)(V-b)=RT$

According to principle of dimensional homogeneity, the dimension of each terms of dimensional equation on both side are same.

So, dimension of a is given as,

$$[P]=\frac{[a]}{[V]^2}$$

$$[a]=[P]\,[V]^2$$
$$=[ML^{-1}T^{-2}]\,[L^3]^2$$
$$=[ML^5T^{-2}]$$

The dimension of b is given as,

$$[b]=[V]$$
$$=[L^3]$$

So, the $\frac{[b]^2}{[a]}=\frac{[L^3]^2}{ML^5T^{-2}}$

$$=\frac{L^6}{ML^5T^{-2}}$$
$$=M^{-1}LT^2$$

$$\beta=\frac{1}{K}$$

($\because$ K = Bulk modulus, β = Compressibility)

$$[\beta]=\frac{1}{ML^{-1}T^{-2}}$$
$$[\beta]=M^{-1}LT^2$$

It is the dimension of compressibility.

98. **Match List I with List II**

	List-I		List-II
A.	Young's Modulus (Y)	1.	$[ML^{-1}T^{-1}]$
B.	Co-efficient of Viscosity (η)	2.	$[ML^2T^{-1}]$
C.	Planck's Constant (h)	3.	$[ML^{-1}T^{-2}]$
D.	Work Function (φ)	4.	$[ML^2T^{-2}]$

Choose the correct answer from the options given below :

(a) A-I, B-III, C-IV, D-II
(b) A-I, B-II, C-III, D-IV
(c) A-II, B-III, C-IV, D-I
(d) A-III, B-I, C-II, D-IV

JEE Main-25.01.2023, Shift-II

Ans. (d) : $(A)\,Y=\frac{FL}{A\Delta L}=\frac{[MLT^{-2}][L]}{[L]^3}=[ML^{-1}T^{-2}]$

$$(B)\,\eta=\frac{Fd}{Av}=\frac{[MLT^{-2}][L]}{[L]^2[LT^{-1}]}=[ML^{-1}T^{-1}]$$

$$(C)\,h=\frac{E\lambda}{C}=\frac{[ML^2T^{-2}][L]}{[LT^{-1}]}=[ML^2T^{-1}]$$

$$(D)\ \phi=h\nu-eV_0=[ML^2T^{-2}]$$

99. **Match List I with List II**

List I	List II
(A) Plank's constant (h)	I. $[M^1L^2T^{-2}]$
(B) Stopping potential (Vs)	II. $[M^1L^1T^{-1}]$
(C) Work function (ϕ)	III. $[M^1L^2T^{-1}]$
(D) Momentum (p)	IV. $[M^1L^2T^{-3}A^{-1}]$

Choose the correct answer from the options given below:

(a) A-II, B-IV, C-III, D-I
(b) A-III, B-IV, C-I, D-II
(c) A-I, B-III, C-IV, D-II
(d) A-III, B-I, C-II, D-IV

JEE Main-24.01.2023, Shift-I

Ans. (b) : $E=h\upsilon$

$$(A)\ h=\frac{E}{\upsilon}=\frac{[ML^2T^{-2}]}{[T^{-1}]}=[ML^2T^{-1}]$$

$$(B)\ V_s=\frac{W}{q}=\frac{[ML^2T^{-2}]}{[AT]}=[ML^2A^{-1}T^{-3}]$$

$$(C)\ \phi=w=[ML^2T^{-2}]$$

$$(D)\ P=mv=[MLT^{-1}]$$

100. **The frequency (υ) of an oscillating liquid drop may depend upon radius (r) of the drop, density (ρ) of liquid and the surface tension (s) of the liquid as $\upsilon=r^a\rho^bs^c$. The values of a, b and c respectively are:**

(a) $\left(-\frac{3}{2},\frac{1}{2},\frac{1}{2}\right)$ (b) $\left(-\frac{3}{2},-\frac{1}{2},\frac{1}{2}\right)$

(c) $\left(\frac{3}{2},\frac{1}{2},-\frac{1}{2}\right)$ (d) $\left(\frac{3}{2},-\frac{1}{2},\frac{1}{2}\right)$

JEE Main-24.01.2023, Shift-II

Ans. (b) : Density $(\rho)=\frac{\text{Mass}(M)}{\text{Volume}(V)}$

$$[\rho]=\frac{[M]}{[V]}=\frac{[M]}{[L^3]}=[ML^{-3}]$$

Surface tension $(s)=\frac{\text{Force}(F)}{\text{Length}(L)}$

$$[s]=\frac{[F]}{[L]}=\frac{[MLT^{-2}]}{[L]}=[MT^{-2}]$$

Dimension of radius

$$[r]=[L]$$

@apna_pdf

Frequency $(\nu) = \frac{1}{T}$

$$[\nu] = \frac{1}{[T]} = [T^{-1}]$$

According to question,

$$\nu = r^a \rho^b s^c$$

$$T^{-1} = [L^a]\,[ML^{-3}]^b\,[MT^{-2}]^c$$

$$M^0L^0T^{-1} = M^{b+c}\,L^{a-3b}\,T^{-2c}$$

By comparing both side, we get–

$$b + c = 0 \quad .....(i)$$

$$a - 3b = 0 \quad .....(ii)$$

$$-2c = -1 \quad .....(iii)$$

$$c = \frac{1}{2}$$

Putting value of c in equation (i), we get–

$$b + \frac{1}{2} = 0$$

$$b = -\frac{1}{2}$$

Putting value of b in equation (ii), we get–

$$a - 3\left(-\frac{1}{2}\right) = 0$$

$$a = -\frac{3}{2}$$

So, the value of a, b and c are $\left(-\frac{3}{2}, -\frac{1}{2}, \frac{1}{2}\right)$.

101. Match List-I with List-II

	List-1		**List-II**
A.	Angular momentum	I.	$[ML^2T^{-2}]$
B.	Torque	II.	$[ML^{-2}T^{-2}]$
C.	Stress	III.	$[ML^2T^{-1}]$
D.	Pressure gradient	IV.	$[ML^{-1}T^{-2}]$

Chose the correct answer from the options given below:

(a) A-IV, B-II, C-I, D-III

(b) A-II, B-III, C-IV, D-I

(c) A-III, B-I, C-IV, D-II

(d) A-I, B-IV, C-III, D-II

JEE Main-31.01.2023, Shift-II

Ans. (c) : (A) Angular momentum (L) = mvr

$$[L] = [m][v][r]$$

$$= [M][LT^{-1}][L]$$

$$= [ML^2T^{-1}]$$

(B) Torque $(\tau) = F \times r$

$$[\tau] = [F]\,[r]$$

$$= [MLT^{-2}]\,[L]$$

$$= [ML^2T^{-2}]$$

(C) Stress $(\sigma) = \frac{F}{A}$

$$[\sigma] = \frac{[F]}{[A]}$$

$$= \frac{[MLT^{-2}]}{[L^2]}$$

$$= [ML^{-1}T^{-2}]$$

(D) Pressure gradient $= \frac{dp}{dx} = \frac{[ML^{-1}T^{-2}]}{[L]}$

$$= [ML^{-2}T^{-2}]$$

102. Match list I with List II :

List-I			**List-II**
(A)	Torque	I	$kg\ m^{-1}\ s^{-2}$
(B)	Energy density	II.	$kg\ ms^{-1}$
(C)	Pressure gradient	III.	$kg\ m^{-2}\ s^{-2}$
(D)	Impulse	IV.	$kg\ m^2\ s^{-2}$

Choose the correct answer from the options given below :

(a) A-IV, B-I, C-III, D-II

(b) A-I, B-IV, C-III, D-I

(c) A-IV, B-III, C-I, D-II

(d) A-IV, B-I, C-II, D-III

JEE Main-30.01.2023, Shift-II

Ans. (a) :

(A) Torque $= F \times r = kgm^2\ sec^{-2}$

(B) Energy density $= \frac{\text{Energy}}{\text{Volume}} = kgm^{-1}\ sec^{-2}$

(C) Pressure gradient $= \frac{dp}{dx} = kgm^{-2}\ sec^{-2}$

(D) Impulse $= F \times t = kgms^{-1}$

103. Electric field in a certain region is given by $\vec{E} = \left(\frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j}\right)$. The SI unit of A and B are:

(a) Nm^2C^{-1}; Nm^3C^{-1}

(b) Nm^3C; Nm^2C

(c) Nm^2C; Nm^3C

(d) Nm^3C^{-1}; Nm^2C^{-1}

JEE Main-30.01.2023, Shift-I

Ans. (a) :

$$E = \frac{A}{x^2}$$

$$NC^{-1} = \frac{A}{m^2} \quad (\because \text{ SI unit of electric field is N/C})$$

$$A = Nm^2C^{-1}$$

$$E = \frac{B}{y^3}$$

$$NC^{-1} = \frac{B}{m^3}$$

$$B = Nm^3C^{-1}$$

@apna_pdf

104. Match list - I with List - II

List-I (Physical Quantity)	List - II (Dimensional Formula)
A. Pressure gradient	I. $[M^0L^2T^{-2}]$
B. Energy density	II. $[M^1L^{-1}T^{-2}]$
C. Electric Field	III. $[M^1L^{-2}T^{-2}]$
D. Latent heat	IV. $[M^1L^1T^{-2}A^{-1}]$

Choose the correct answer from the options given below:

(a) A-II, B-III, C-I, D-IV
(b) A-III, B-II, C-IV, D-I
(c) A-II, B-III, C-IV, D-I
(d) A-III, B-II, C-I, D-IV

JEE Main-29.01.2023, Shift-I

Ans. (b) :

(A) Pressure gradient $= \dfrac{dp}{dx} = \dfrac{F}{A.L}$

$$= \frac{[MLT^{-2}]}{[L^3]} = [M^1L^{-2}T^{-2}]$$

(B) Energy density $= \dfrac{\text{Energy}}{\text{Volume}} = \dfrac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

(C) Electric field $= \dfrac{F}{q} = \dfrac{[MLT^{-2}]}{[AT]} = [M^1L^1T^{-3}A^{-1}]$

(D) Latent heat $= \dfrac{\text{Heat}}{\text{mass}} = \dfrac{\text{energy}}{\text{mass}} = \dfrac{[ML^2T^{-2}]}{[M]} = [L^2T^{-2}]$

105. If the velocity of light c, universal gravitational constant G and Planck's constant h are chosen as fundamental quantities. The dimensions of mass in the new system is :

(a) $[h^1c^1G^{-1}]$
(b) $[h^{-1/2}c^{1/2}G^{1/2}]$
(c) $[h^{1/2}c^{1/2}G^{-1/2}]$
(d) $[h^{1/2}c^{-1/2}G^1]$

JEE Main-01.02.2023, Shift-II

Ans. (c) :

$$[M] = [G]^a\,[h]^b[C]^c$$
$$[G] = [M^{-1}L^3T^{-2}];\ [h] = [ML^2T^{-1}]$$
$$[C] = [LT^{-1}]$$
$$[M] = [M^{-1}L^3T^{-2}]^a\,[ML^2T^{-1}]^b[LT^{-1}]^c$$
$$M^1L^0T^0 = M^{-a+b}\,L^{3a+2b+c}\,T^{-2a-b-c}$$

On comparing both side, we get–

$-a + b = 1$ .....(i)

$3a + 2b + c = 0$ .....(ii)

$-2a - b - c = 0$ .....(iii)

On solving equation (i), (ii) and (iii), we get–

$a = \dfrac{-1}{2}$

$b = 1/2$

$c = 1/2$

$[M] = [h^{1/2}c^{1/2}G^{-1/2}]$

106. The physical quantity having the dimensions $[M^{-1}L^{-3}T^3A^2]$ is

(a) resistance
(b) resistivity
(c) electrical conductivity
(d) electromotive force

J&K-CET-2012, JCECE-2009
Karnataka CET-2006

Ans. (c) : Resistivity $(\rho) = \dfrac{RA}{l}$

$$R = \frac{V}{I} \text{ and } V = \frac{W}{Q}$$

So, $\rho = \dfrac{W}{QI}\cdot\dfrac{A}{l}$

dimension of $(\rho) = \dfrac{[ML^2T^{-2}][L^2]}{[AT][A][L]} = [ML^3A^{-2}T^{-3}]$

Electrical conductivity $\sigma = \dfrac{1}{\rho} = [M^{-1}L^{-3}T^3A^2]$

Resistance $= \dfrac{\text{resistivity} \times \text{length}}{\text{area}}$

$$= [ML^3T^{-3}A^{-2}]\frac{[L]}{[L^2]} = [ML^2T^{-3}A^{-2}]$$

Electromotive force = resistance × current

$$= [ML^2T^{-3}A^{-2}][A]$$
$$= [ML^2T^{-3}A^{-1}]$$

107. The dimension of $\dfrac{a}{b}$ in the equation $p = \dfrac{a - t^2}{bx}$, where p is pressure, x is distance and t is time is

(a) $[LT^{-3}]$
(b) $[ML^3T^{-1}]$
(c) $[M^2LT^{-3}]$
(d) $[MT^{-2}]$

JCECE-2011, CG-PET-2014
Karnataka CET-2003
UPSEE - 2013

Ans. (d) :

Dimension of pressure $[P] = \dfrac{[F]}{[A]} = \dfrac{[MLT^{-2}]}{[L^2]}$

$$[P] = [M^{+1}L^{-1}T^{-2}]$$

Dimension of Distance $(x) = [L]$

Dimension of Time (t) $= [T^1]$

$$P = \frac{a - t^2}{bx} = \frac{a}{bx} - \frac{t^2}{bx}$$

Dimension of P = Dimension of $\dfrac{a}{bx}$

$$[P] = [ML^{-1}T^{-2}]$$

$$[ML^{-1}T^{-2}] = \left[\frac{a}{b}\right]\frac{1}{[L]}$$

The dimension of $\left[\dfrac{a}{b}\right] = [MT^{-2}]$

@apna_pdf

108. $[ML^{-1}T^{-1}]$ stand for dimension of

(a) work
(b) torque
(c) linear momentum
(d) coefficient of viscosity

UPSEE - 2013, 2011, J&K CET- 2010, 1998
AIIMS-2010, AIEEE 2004, UP CPMT-2001

Ans. (d) :

(i) Dimension of work

$W = f.d$

$W = [MLT^{-2}]\,[L] = [ML^2T^{-2}]$

(ii) Dimension of torque

$T = f \times r$

$= [MLT^{-2}]\,[L]$

$T = [ML^2T^{-2}]$

(iii) Linear momentum

$P = m.v.$

$= [M]\,[LT^{-1}] = [MLT^{-1}]$

(iv) Dimension of coefficient of viscosity

$F = 6\pi\eta rv$

$$\eta = \frac{F}{6\pi r.v}$$

$$= \frac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$$

109. If p represents radiation pressure, c represents speed of light and S represents radiation energy striking unit area per sec. The non-zero integers x, y, z such that $p^x\ S^y\ c^z$ is dimensionless are

(a) $x = 1, y = 1, z = 1$ (b) $x = -1, y = 1, z = 1$
(c) $x = 1, y = -1, z = 1$ (d) $x = 1, y = 1, z = -1$

[AIPMT 1992], UPCPMT-1992, 1981
AFMC-1991, MP PMT-1992

Ans. (c) : Given,

P = radiation pressure
C = speed of light
S = radiation energy

x,y and z are non zero intezers.

$[P^x\ S^y\ C^z] = [M^0L^0T^0]$ …(i)

The dimension of P = $[ML^{-1}T^{-2}]$

The dimension of S = $[MT^{-3}]$

The dimension of C = $[LT^{-1}]$

Putting the dimension in equation (i)

$[ML^{-1}T^{-2}]^x\ [MT^{-3}]^y.\ [LT^{-1}]^z = [M^0L^0T^0]$

$[M^{x+y}.L^{-x+z}.T^{-2x-3y-z}] = [M^0L^0T^0]$

$x + y = 0$ …(ii)

$z - x = 0$ …(iii)

$-2x - 3y - z = 0$ …(iv)

From equation (iii)

$x = z$

From equation (ii)

$\therefore\ z = -y$

By solving, we get,

$x = 1, y = -1, z = 1$

Hence, option (c) is correct.

110. The dimensional formula for permeability of free space, μ_0 is

(a) $[MLT^{-2}A^{-2}]$ (b) $[ML{-}1T^{-2}A^2]$
(c) $[ML^{-1}T^{-2}A^2]$ (d) $[MLT^{-2}A^{-1}]$

UPCPMT-2007, AIIMS-2003
AFMC-2002, AIPMT-1993, 1991
MP PET-1997

Ans. (a) : The dimensional formula for permeability of free space,

$$\mu_0 = \frac{2\pi \times \text{force} \times \text{distance}}{\text{current} \times \text{current} \times \text{length}}$$

Dimension of force = $[MLT^{-2}]$

Dimension of current = [A]

Dimension of length and distance = [L]

$$\therefore \mu_0 = \frac{[MLT^{-2}][L]}{[A][A][L]}$$

$$\mu_0 = [MLT^{-2}A^{-2}]$$

111. The frequency of vibration f of a mass m suspended from a spring of spring constant k is given by a relation of the type $f = Cm^x\ k^y$, where C is a dimensionless constant. The values of x and y are

(a) $x = \frac{1}{2}, y = \frac{1}{2}$ (b) $x = -\frac{1}{2}, y = -\frac{1}{2}$
(c) $x = \frac{1}{2}, y = -\frac{1}{2}$ (d) $x = -\frac{1}{2}, y = \frac{1}{2}$

[AIPMT 1990], RPMT-1998, MP PET-2013

Ans. (d) : Given,

$f = Cm^x.K^y$

where, C = dimensionless constant
m = mass
K = spring constant

The dimension of frequency, f = $[T^{-1}]$

The dimension of mass, m = [M]

The dimension of spring constant, k = $[MT^{-2}]$

$F = Cm^x.K^y$

$[M^0L^0T^{-1}] = [M]^x\ [MT^{-2}]^y$

$[M^0L^0T^{-1}] = [M^{x+y}.\ T^{-2y}]$

$x + y = 0$ and $-2y = -1$

$x = -y$ and $y = \frac{1}{2}$

$\Rightarrow\ x = -\frac{1}{2}, y = \frac{1}{2}$

112. If C and R denote capacitance and resistance respectively, then the dimensional formula of CR is

(a) $[M^0L^0T]$
(b) $[M^0L^0T^0]$
(c) $[M^0L^0T^{-1}]$
(d) Not expressible in terms of [MLT]

[AIPMT-1995, 1992, 1988]
UPCPMT-2005, 1985, 1981
Punjab PMT-1999, MP PMT-2006

@apna_pdf

Ans. (a) :

Capacitance $(C)=\frac{q}{v}=\frac{q}{\frac{w}{q}}=\frac{q^2}{w}=\frac{(it)^2}{F.d}$

Where q = charge

C = Capacitance

v = voltage

$$=\frac{(it)^2}{Fx}=\frac{[AT]^2}{[ML^2T^{-2}]}$$

$$=[M^{-1}L^{-2}T^4A^2]$$

and $R=\frac{V}{i}=\frac{w}{qi}=\frac{F.d}{i^2.t}=\frac{[MLT^{-2}][L]}{[A]^2[T]}$

$[ML^2T^{-3}A^{-2}]$

Dimensional formula of CR

$=[M^{-1}L^{-2}T^4A^2][ML^2T^{-3}A^{-2}]$

$=[M^0L^0T^1]$

113. The dimensions of impulse is :

(a) $[MLT^{-2}]$ (b) $[M^2LT^{-1}]$

(c) $[MLT^{-1}]$ (d) $[ML^2T^{-1}]$

AP EAMCET(Medical)-1998

J&K CET- 2011, CPMT-1978

EAMCET-1981, AIPMT-1991

AFMC-1998, BCECE-2003, KCET-2007

Ans. (c) : Impulse (I) = Force × Time

Force = $[M^1L^1T^{-2}]$

Time = [T]

Hence, $I=[M^1L^1T^{-2}][T]$

$I=[M^1L^1T^{-1}]$

114. If power (P), surface, tension (T) and Planck's constant (h) are arranged, so that the dimensions of time in their dimensional formulae are in ascending order, then which of the following is correct?

(a) P, T, h (b) P, h, T

(c) T, P, h (d) T, h, p

AP EMCET(Medical)-2008

CPMT-1974, EAMCET-1981

SCRA-1989, MP PMT-2001, 1996

MP PET-2007

Ans. (a) :

Power $\boxed{P=\frac{w}{T}}$

$$[P]=\frac{[ML^2T^{-2}]}{[T]}=[ML^2T^{-3}]$$

Surface Tension, $\boxed{T=\frac{F}{L}}$

$$[T]=\frac{[MLT^{-2}]}{[L]}=[ML^0T^{-2}]$$

Photon energy, $E=h\nu$

$$h=\frac{E}{\nu}$$

Planck's constant= $\boxed{h=\frac{[ML^2T^{-2}]}{[T^{-1}]}}=[ML^2T^{-1}]$

$\therefore$ The ascending order of dimensions of time in the dimensional formula P, T, h

115. The dimensional formula for latent heat is

(a) $[MLT^{-2}]$ (b) $[ML^2T^{-2}]$

(c) $[M^0L^2T^{-2}]$ (d) $[MIT^{-1}]$

EAMCET-1999, UPCPMT-1986, 1978

IIT-1989, 1983, MNR-1987

Karnataka CET-2001, RPET-2002

Ans. (c) : Formula of latent heat given by $L=\frac{Q}{m}$

Where, L= latent heat

Q= amount of heat

M = mass of substance

Dimension of heat or work = force × displacement

$=[M\,L\,T^{-2}]\,[L]$

$=[M\,L^2\,T^{-2}]$

Dimension of mass = [M]

Dimension of Latent heat $L=\frac{\text{dim.of } Q}{\text{dim.of } m}$

$=[M\,L^2T^{-2}].\,[M]^{-1}$

$=[M^0L^2T^{-2}]$

116. Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be

(a) $[ML^2T^{-3}I^{-1}]$ (b) $[ML^2T^{-2}]$

(c) $[ML^2T^{-1}I^{-1}]$ (d) $[ML^2T^{-3}I^{-2}]$

JIPMER-2009, JCECE-2018

AIIMS-2005, UPCPMT-2008, [AIPMT 2007]

Ans. (d) : From the relation of ohm's law-

V = IR

Where – V = Voltage

I = current of the circuit

R = Resistance of the wire

or

$$R=\frac{V}{I}\qquad\left(\because\ V=\frac{W}{q}\right)$$

$$\therefore\qquad R=\frac{W}{q.I}\qquad(\because\ q=I.t)$$

or

$$R=\frac{W}{I.t.I}=\frac{[ML^2T^{-2}]}{[IT][I]}$$

or

$R=[ML^2T^{-3}I^{-2}]$

@apna_pdf

117. If M, L, T, and I stand for mass, length, time and electric current respectively, the dimensional formula for capacitance is

(a) $[M^{-1}L^2T^{-4}I^2]$ (b) $[M^{-1}L^{-2}T^4I^2]$

(c) $[ML^2T^4I^2]$ (d) $[ML^2T^{-4}I^{-2}]$

AIIMS-25.05.2019 (E)-Shift-II
UPSEE - 2012, AMU (Medical)-2002
EAMCET-1998, IIT-1983
AP EAMCET(Medical)-1997

Ans. (b) : Capacitance = $\dfrac{\text{charge}}{\text{voltage}}$

Capacitance = charge × voltage^{-1} …….. (i)

Dim. of charge = [IT]

Voltage = Electric field × displacement

Electric field = force × charge^{-1}

$= [M\,L\,T^{-2}] \times [IT]^{-1}$

Dim. (Electric field) = $[ML^1T^{-3}I^{-1}]$

Now, dimension of voltage = $[MLI^{-1}T^{-3}]\,[L]$

$= [M\,L^2\,I^{-1}\,T^{-3}]$

Put in the equation (i),

Dim. (Capacitance) = $[IT] \times [M\,L^2\,I^{-1}\,T^{-3}]^{-1}$

$= [M^{-1}\,L^{-2}\,T^4\,I^2]$

118. The dimensional formula for Young's modulus is

OR

The dimensional formula of modulus of rigidity is

OR

The dimensional formula of pressure is

OR

The dimensional formula for volume elasticity is

OR

The dimensional formula of modulus of elasticity is

OR

Dimension of Bulk modulus is

OR

What is the dimension of stress?

(a) $ML^{-1}T^{-2}$ (b) M^0LT^{-2}

(c) MLT^{-2} (d) ML^2T^{-2}

NEET (Sep.) 2020, SRMJEEE-2017
Kerala CEE-2019, UPSEE-2010
CG PET- 2012, 2009, DCE-2007
JIPMER-2005, MP PET-2000, 1991
UP CPMT-2004, 1991
AP EAMCET (Med.)-1995
Manipal-1995, Punjab PMT-2001
AIPMT-1990, IIT-1982
MNREC-1986, 1984

Ans. (a) : Young's modulus = $\dfrac{\text{stress}}{\text{strain}}$

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

$$\text{Strain} = \frac{\Delta l}{l} \Rightarrow \frac{[L]}{[L]} = [M^0L^0T^0]$$

$$\text{Dimension of Young's modulus} = \frac{[ML^{-1}T^{-2}]}{[M^0L^0T^0]}$$

Dimensional formula of Young's modulus = $[ML^{-1}T^{-2}]$

119. The dimension of light year

(a) $[LT^{-1}]$ (b) [T]

(c) $[ML^2T^{-2}]$ (d) [L]

TS EAMCET 28.09.2020, Shift-I
MP PMT-1989, UPCPMT-1991
AFMC-2005, 1991

Ans. (d) : Light year is a distance that light can travel in one year since its unit is in meter.

∴ Dimension of light year is [L]

120. Dimensional formula for ε_0 is

(a) $[M^{-1}L^{-2}A^2T^2]$ (b) $[ML^2A^{-2}T^4]$

(c) $[M^{-1}L^{-3}A^2T^4]$ (d) $[ML^3A^{-2}T^4]$

AP EAMCET (17.09.2020) Shift-II
Kerala CEE -2018, JCECE-2017
BCECE-2010, CG PET- 2007, 2006
UPSEE - 2005, AIIMS-2004, AMU-2003

Ans. (c) : From Coulomb's law,

$$F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2}$$

$$\therefore \quad \varepsilon_0 = \frac{1}{4\pi F}\cdot\frac{q_1q_2}{r^2}$$

$$\therefore \text{ Dimensions of } \varepsilon_0 = \frac{1}{[MLT^{-2}]} \times \frac{[AT]^2}{[L^2]}$$

$$= [M^{-1}L^{-3}A^2T^4]$$

121. Dimensions of $1/\mu_0\varepsilon_0$, where symbols have their usual meaning, are

(a) $[L^{-1}T]$ (b) $[L^2T^2]$

(c) $[L^2T^{-2}]$ (d) $[LT^{-1}]$

MP PMT-1991, 1989, 1987
J&K CET-2010, DPMT-2004
AIEEE 2003, Bihar PET-1984
AFMC-1986, AIIMS-1993
AIPMT-1992, UPCPMT-1997, 1992
Karnataka CET-1994, DCE-1999

Ans. (c) : We know,

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$c^2 = \frac{1}{\mu_0\varepsilon_0}$$

Then, dimensional formula of $\dfrac{1}{\mu_0\varepsilon_0}$ is given as –

$$\frac{1}{\mu_0\varepsilon_0} = c^2 = [LT^{-1}]^2 = [L^2T^{-2}]$$

@apna_pdf

122. Planck's constant has the dimensions of

(a) linear momentum (b) angular momentum

(c) energy (d) power

TS EAMCET 31.07.2022, Shift-II
AP EAMCET-06.09.2021, Shift-I
Kerala CEE 2007, Karnataka CET-2004
AIPMT-2001

Ans. (b) : We know that, E = hν

Where, E = Energy, h = Planck's constant,

ν = Frequency

Dimension of Plank's constant

$$h = \frac{E}{\nu}$$

$$h = \frac{[ML^2T^{-2}]}{[M^0L^0T^{-1}]}$$

$$h = [ML^2T^{-1}]$$

Dimension of Angular momentum

$$= MVr$$
$$= [M][LT^{-1}]\ [L]$$
$$= [ML^2T^{-1}]$$

Hence, option (b) is correct.

123. Dimensions of Planck's constant is :

(a) $[ML^2T^{-1}]$ (b) $[MLT^{-2}]$

(c) $[ML^{-2}T]$ (d) $[ML^{-1}T^2]$

J&K CET- 2015, 2003, 1999
DCE-2007, BCECE-2004
AFMC-2003, Kerala PMT-2002
AIIMS-1997, MP PMT-1996, 1983
IIT-1985, DPMT-1987, MP PET-1995
RPMT-1999, UPCPMT-1999

Ans. (a) : Formula, E = hν

$$\text{Planck's Constant }(h) = \frac{\text{Energy in each Photon}}{\text{Frequency of radiation}}$$

$$= \frac{E}{\nu} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$$

$$= [ML^2T^{-1}]$$

124. The dimension of magnetic flux is

(a) $[MLT^{-1}A^{-1}]$ (b) $[ML^{-1}TA^{-2}]$

(c) $[ML^{-2}T^2A^{-2}]$ (d) $[ML^2T^{-2}A^{-1}]$

J&K-CET-2015, GUJCET-2014
Odisha-JEE-2012, Kerala PMT-2005
Kerala CEE 2005, DPMT-2001
AP EAMCET (Medical)-2003
AIPMT-1999, 89, AIIMS-1998
MP PMT-1994, DCE-1993, IIT-1982

Ans. (d) : Magnetic flux $(\phi_B) = B \times A \times \cos\theta$

Where, B = Magnetic Field

A = Surface Area

θ = Angle between the magnetic field and normal to the surface.

$$\text{Therefore, dim. }(\phi_B) = [M^1T^{-2}A^{-1}][M^0L^2T^0]$$

$$\phi_B = [M^1L^2T^{-2}A^{-1}]$$

Since, θ is a dimensionless quantity.

125. The equation of state of some gases can be expressed as

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT$$

where, p is the pressure, V the volume, T the absolute temperature and a and b are constants. The dimensional formula of a is

(a) $[ML^5T^{-2}]$ (b) $[M^{-1}L^5T^{-2}]$

(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-5}T^{-2}]$

WB JEE-2013, JCECE-2010
CG-PET-2009, Odisha PMT-2004
UPSEE-2002, UPCPMT-1997
AIMPMT-1996, MNR-1995
AFMC-1995, MP PMT-1994, MPPET-1992

Ans. (a) : According to the principle of dimensional homogeneity the dimensions of each the terms of a dimensional equation on both sides are the same.

So, dimension of p and $\frac{a}{V^2}$ will be same

$$p = \left[\frac{a}{V^2}\right]$$

$$a = [p][V^2]$$

$$a = [ML^{-1}T^{-2}][L^6]$$

$$a = [ML^5T^{-2}]$$

126. The dimensions of universal gravitational constant are–

(a) $[M^{-2}L^{-3}T^{-2}]$ (b) $[M^{-2}L^2T^{-1}]$

(c) $[M^{-1}L^3T^{-2}]$ (d) $[ML^2T^{-2}]$

AP EAMCET-23.09.2020, Shift-II
WB JEE 2017, COMEDK 2014
BCECE-2013, 2005, Kerala PMT-2012
Odisha JEE-2010, Karnataka CET- 2008
CG PET- 2004, JIPMER-2004
Punjab PMT-2003, AIIMS-2000
MP PMT-2000, AFMC-1999
UPCPMT-1996, DPMT-1984
EAMCET-1992, AIPMT-2004, 1992

Ans. (c) : Gravitational force acting between two body is–

$$F = \frac{Gm_1m_2}{r^2}$$

$$\therefore \quad G = \frac{F.\,r^2}{m_1.\,m_2}$$

Where, G = Universal gravitational constant

F = Gravitational force

m_1 = mass of first body

m_2 = mass of second body

@apna_pdf

r = Distance between two body.

$\therefore$ Unit of Universal gravitational constant–

$$\Rightarrow \text{ Unit of } G = \frac{\text{Newton. m}^2}{\text{kg . kg}} = \frac{\text{N.m}^2}{(\text{Kg})^2}$$

$$\Rightarrow \text{ Dimension of G = Dimension of } \frac{\text{N.m}^2}{(\text{Kg})^2}$$

$$\Rightarrow \text{ Dimension of } G = \frac{\left[MLT^{-2}\right]\left[L^2\right]}{\left[M^2\right]}$$

$$\Rightarrow \text{ Dimension of } G = \left[M^{-1}\,L^3\,T^{-2}\right]$$

127. The dimensions of self inductance *L* are

(a) $[ML^2T^{-2}A^{-2}]$ (b) $[ML^2T^{-1}A^{-2}]$

(c) $[ML^2T^{-1}A^{-1}]$ (d) $[ML^{-2}T^{-2}A^{-2}]$

MP PET-2009, UPSEE –2008, 2014
J&K CET-2005, Karnataka CET-2004
KCET-2004, DPMT-1999
CPMT-1992, IIT-1983, AIPMT-1992, 1989

Ans. (a) : We know that,

$$E = L\frac{di}{dt}$$

where is 'i' is the current of circuit and L is the self inductance.

$$L = \frac{|E|}{\frac{di}{dt}} = \frac{[ML^2T^{-3}A^{-1}]}{[AT^{-1}]}$$

$$[L] = [ML^2T^{-2}A^{-2}]$$

128. Dimensional formula of Stefan's constant is

(a) $[MT^{-3}K^{-4}]$ (b) $[ML^0T^{-2}K^{-4}]$

(c) $[ML^2T^{-2}]$ (d) $[MT^{-2}L^0]$

(e) $[MT^{-4}L^0]$

Manipal UGET -2020, Kerala CEE - 2009
KCET-2006, AIPMT-2002, MP PET-1992
MP PMT-1992, 1989, AFMC-1986

Ans. (a) : Stefan's constant $(\sigma) = \dfrac{E}{AtT^4}$

$$[\sigma] = \frac{[ML^2T^{-2}]}{[L^2][K^4][T]}$$

$$[\sigma] = \frac{[ML^0T^{-3}]}{[K]^4}$$

Dimension of $(\sigma) = [ML^0T^{-3}K^{-4}]$

129. If the force is given by F = at + bt^2 with t as time. The dimensions of a and b are

(a) $[MLT^{-4}]$ and $[MLT^{-2}]$

(b) $[MLT^{-3}]$ and $[MLT^{-4}]$

(c) $[ML^2T^{-3}]$ and $[ML^2T^{-2}]$

(d) $[ML^2T^{-3}]$ and $[ML^3T^{-4}]$

JIPMER-2013, 2005, BITSAT-2012
Kerala PET-2011, Kerala CEE - 2011
AP EAMCET -2010, BCECE-2003
BHU-2005, 1998, AFMC-2001

Ans. (b) : Given, $F = at + bt^2$

Dimension of F = Dimension of at

$$\left[MLT^{-2}\right] = a\left[T\right]$$

$$a = \frac{\left[MLT^{-2}\right]}{\left[T\right]}$$

$$a = [MLT^{-3}]$$

Dimension of F = Dimension of bt^2

$$F = bt^2$$

$$\left[MLT^{-2}\right] = b\left[T\right]^2$$

$$b = \frac{\left[MLT^{-2}\right]}{\left[T^2\right]}$$

$$b = [MLT^{-4}]$$

130. The correct dimensional formula for impulse is given by

(a) $[ML^2T^{-2}]$ (b) $[MLT^{-1}]$

(c) $[ML^2T^{-1}]$ (d) $[MLT^{-2}]$

WB JEE 2019, AIPMT-1991
AFMC-1998, BCECE-2003
Karnataka CET-2007, UPCPMT-1978
AP EAMCET-1981

Ans. (b) : Impulse (I) = Force × time

$$[M^1L^1T^{-2}] \times [T]$$

$$[I] = [M^1L^1T^{-1}]$$

131. The dimension of angular momentum is

(a) $[M^0L^1T^{-1}]$ (b) $[M^1L^2T^{-2}]$

(c) $[M^1L^2T^{-1}]$ (d) $[M^2L^1T^{-2}]$

UPCPMT-1999, 1989, 1986, 1982, 1973
WB JEE-2012, AIPMT-1988
BCECE-2004, Punjab PET-2000
DPMT-1987, IIT-1983, VIT-1982
MP PMT-1987, AIPMT-1992, 1988, BHU-1995

Ans. (c) : We know

Angular momentum (L) = mvr.

where = m = mass (kg)
V = velocity (m/s)
r = radius (m)

$$L = [\,M\,]\,[\,LT^{-1}]\,[\,L\,]$$

$$L = [\,M^1L^2T^{-1}]$$

132. The speed of light (c), gravitation constant (G), and Plank's constant (h) are taken as the fundamental units in a system. The dimension of time in this new system should be:

(a) $\left[G^{1/2}\,h^{1/2}\,c^{-5/2}\right]$ (b) $\left[G^{-1/2}\,h^{1/2}\,c^{1/2}\right]$

(c) $\left[G^{1/2}\,h^{1/2}\,c^{-3/2}\right]$ (d) $\left[G^{1/2}\,h^{1/2}\,c^{1/2}\right]$

CG PET-22.05.2022
AIIMS-2008, AMU-1999

@apna_pdf

Ans. (a) : dimension

$$[C] = LT^{-1}$$

$$[G] = M^{-1}L^3T^{-2}$$

$$[h] = M^1L^2T^{-1}$$

Let $\quad t \propto c^x\ G^y h^z$

$$T = \left(LT^{-1}\right)^x \left(M^{-1}L^3T^{-2}\right)^y \left(ML^2T^{-1}\right)^z$$

$$= [M]^{-y+z}\ [L]^{x+3y+2z}\ [T]^{-x-2y-z}$$

By equating

$$-y + z = 0 \quad \_\_\_(i)$$

$$x + 3y + 2z = 0 \quad \_\_\_(ii)$$

$$-x - 2y - z = 1 \quad \_\_\_(iii)$$

By Solving eq^n (i), (ii) & (iii)

We get, $x = \frac{-5}{2},\ y = \frac{1}{2},\ z = \frac{1}{2}$

$$[t] = \left[C^{-5/2}G^{1/2}h^{1/2}\right]$$

133. The dimensions of Boltzmann constant are

(a) $\left[ML^2T^{-2}\theta^{-1}\right]$ (b) $\left[ML^2T^{-2}\theta\right]$

(c) $\left[M^2LT^{-2}\theta^{-1}\right]$ (d) $\left[ML^0T^{-2}\theta^{-1}\right]$

AP EAMCET-08.07.2022, Shift-I
CG PET- 22.05.2022
AIIMS-26.05.2019(E) Shift-2
CG PET-2010, MP PET-2013, 2002
Punjab PET-2001

Ans. (a) : Dimensional formula of Boltzmann constant

$$(K_b) = \frac{\text{Dimensional formula of energy}}{\text{Dimensional formula of temperature}}$$

$$= \frac{[ML^2T^{-2}]}{[\theta]}$$

$$= [ML^2T^{-2}\theta^{-1}]$$

134. If velocity (V), acceleration (A) and force (F) are considered as fundamental units then the dimension of Young's modulus will be

(a) $[FA^2V^{-5}]$ (b) $[FA^2V^{-4}]$

(c) $[FA^2V^{-3}]$ (d) $[FA^2V^2]$

Tripura-27.04.2022
JEE Main-11.01.2019, Shift-II
JEE Main-02.09.2020, Shift-1

Ans. (b) : Velocity = ν

Acceleration = A

Force = F

We know that,

The dimension of young's

Modulus, $Y = \frac{\text{stress}}{\text{strain}} = \left[ML^{-1}T^{-2}\right]$

Then according to the dimension rule

$[Y] = [F]^a\ [A]^b\ [V]^c$ ……….(i)

$[ML^{-1}T^{-2}] = [MLT^{-2}]^a\ [LT^{-2}]^b\ [LT^{-1}]^c$

$[ML^{-1}T^{-2}] = [M^a\ L^{a+b+c}\ T^{-2a-2b-c}]$

comparing both side, we get

$a = 1$

$a + b + c = -1$

$-2a - 2b - c = -2$

On solving the equation we get

$a = 1,\ b = 2,\ c = -4$

Putting the value of a, b, and c in equation (1)

$[Y] = [FA^2\ V^{-4}]$.

135. Dimensional formula of electric flux________

(a) $[M^1\ L^{-3}\ T^{-3}\ A^{-1}]$ (b) $[M^1\ L^3\ T^3\ A^{-1}]$

(c) $[M^1\ L^{-3}\ T^{-3}\ A^{-1}]$ (d) $[M^{-1}\ L^3\ T^{-3}\ A^{-1}]$

GUJCET 18.04.2022

Ans. (c) : Electric flux

$$\phi = B.A$$

$$= \frac{F}{q}.A$$

Unit of $\phi = Nm^2c^{-1}$ or $kg\ m^3s^{-2}\ c^{-1}$

$$\text{Dimensions} = \frac{F}{q}.A$$

$$\frac{[MLT^{-2}][L^2]}{[AT]}$$

$$\phi = [ML^3T^{-3}A^{-1}]$$

136. The dimensional formula for the power of a lens is

(a) $[L^{-1}M^0T^0]$ (b) $[L^0M^{-1}T^0]$

(c) $[L^0M^0T^{-1}]$ (d) $[L^0M^0T^0]$

(e) $[L^{-1}M^0T^{-1}]$

Kerala CEE 04.07.2022

Ans. (a) : We know, $P = \frac{1}{f(m)}$

F = Focal length

The dimension of focal length is $\left[M^0L^1T^0\right]$

Then the dimensional formula for the power of a lens

$P = [L^{-1}M^0T^0]$

137. If E and E_0 denote energies at time t and t_0 respectively, and L and L_0 distance from some point at t and t_0 respectively, then which of the following equations can be declared to be incorrect on dimensional grounds.

(A) $E = \frac{2E_0L}{L_0}$ **(B)** $E = E_0e^{-2L/L_0}$

(C) $E = 2Le^{-L/E_0}$ **(D)** $E = 2(E_0/L_0) \times e^{-L/L_0}$

(a) A, B only (b) A, C only

(c) A, C, D only (d) C, D only

TS EAMCET 18.07.2022, Shift-I

Ans. (d) : In C, the dimension of E and L are different.

Similarly in D, E and $\frac{E_0}{L_0}$ also have different dimension.

So, C and D is incorrect on dimensional ground.

$$[E] \neq [L]$$

$$[E] \neq \left[\frac{E_0}{L}\right]$$

@apna_pdf

138. If the velocity of light C, the gravitational constant G and Planck's constant h are chosen as the fundamental units, the dimension of density in the new system is

(a) $[C^3G^{-2}h^1]$ (b) $[C^5G^{-2}h^{-1}]$

(c) $[C^{-3/2}G^{-1/2}h^{1/2}]$ (d) $[C^{9/2}G^{-1/2}h^{-1/2}]$

TS EAMCET 20.07.2022, Shift-I

Ans. (b) : Given,

Speed of Light (C) = $[LT^{-1}]$

Gravitational constant (G) = $[M^{-1}L^3T^{-2}]$

Planck's constant (h) = $[ML^2T^{-1}]$

$$\text{Let } [ML^{-3}] = [C^xG^yh^z]$$
$$= [LT^{-1}]^x.[M^{-1}L^3T^{-2}].[ML^2T^{-1}]^z$$
$$= [M^{-y+z}.L^{x+3y+2z}.T^{-x-2y-z}]$$

Where,

$$-y+z=1,\quad x+3y+2z=-3,\quad -x-2y-z=0$$
$$x=5,\quad y=-2,\quad z=-1$$

So, the dimension of $[ML^{-3}] = [C^5\,G^{-2}\,h^{-1}]$

139. Given below are two statements: One is labelled as Assertion (A) and other is labelled as Reason (R).

Assertion (A) : Time period of oscillation of a liquid drop depends on surface tension (S), if density of the liquid is ρ and radius of the drop is r, then $T = K\sqrt{\rho r^3/S^{\frac{3}{2}}}$ is dimensionally correct, where K is dimensionless

Reason (R) : Using dimensional analysis we get R.H.S. having different dimension than that of time period.

In the light of above statements, choose the correct answer from the options given below.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(c) (A) is true but (R) is false

(d) (A) is false but (R) is true

JEE Main-29.07.2022, Shift-I

Ans. (d) :

$$T = \sqrt{\rho r^3/(S)^{3/2}} \;\cdots\cdots\; (i)$$

Dimensional formula of the given parameters T, r,ρ and S –

$$T=[T],\; r=[L],\; \rho=[ML^{-3}],\; S=[MT^{-2}]$$

$$\text{R.H.S} \Rightarrow \quad \sqrt{\rho r^3/(S)^{3/2}} = \sqrt{\frac{(ML^{-3})(L)^3}{(MT^{-2})^{3/2}}}$$
$$= \left[\frac{(M)}{M^{3/2}T^{-3}}\right]^{1/2}$$
$$= \left[\frac{M^{\frac{1}{2}}}{M^{\frac{3}{4}}T^{\frac{-3}{2}}}\right] = \left[M^{\frac{-1}{4}}T^{\frac{3}{2}}\right]$$

$\therefore$ Dimensional formula of R.H.S = $\left[M^{\frac{-1}{4}}T^{3/2}\right]$

And dimensional formula of L.H.S = [T]

$\therefore$ L.H.S ≠ R.H.S

So, Left hand side and right hand side is not dimensionally correct and their dimension is not same.

140. The dimensions of $\left(\frac{B^2}{\mu_0}\right)$ will be :

(if μ_0 : permeability of free space and B : magnetic field)

(a) $[ML^2T^{-2}]$ (b) $[MLT^{-2}]$

(c) $[ML^{-1}T^{-2}]$ (d) $[ML^2T^{-2}A^{-1}]$

JEE Main-28.07.2022, Shift-I

Ans. (c) : $\frac{B^2}{2\mu_0}$ = Magnetic Energy density

$$\left[\frac{B^2}{\mu_0}\right] = \frac{[\text{Energy}]}{[\text{Volume}]} = \left[\frac{M^1L^2T^{-2}}{L^3}\right] = [M^{+1}L^{-1}T^{-2}]$$

141. Given below are two statements : One is labeled as Assertion A and the other is labeled as Reason R.

Assertion A : Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

Reason R: Coefficient of viscosity

$$= \frac{\text{Force}}{\text{Velocity gradient}}$$

Choose the correct answer from the options given below.

(a) Both A and R true and R is correct explanation of A.

(b) Both A and R are true but R is NOT the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

JEE Main-28.06.2022, Shift-I

Ans. (c) The dimension of product of pressure and time $= [ML^{-1}T^{-2}]\,[T^1] = [ML^{-1}T^{-1}]$

$\because$ Coefficient of viscosity $\eta = \frac{F}{6\pi rv}$

$$\text{Dimension of } \eta = \frac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$$

$$\text{R: Coefficient of viscosity} = \frac{\text{Force}}{\text{Velocity gradient}}$$

$$\frac{[MLT^{-2}]}{[LT^{-1}][L^{-1}]} = [MLT^{-1}]$$

So, assertion is true but reason is falls.

@apna_pdf

142. The dimension of mutual inductance is:

(a) $\left[ML^2T^{-2}A^{-1}\right]$ (b) $\left[ML^2T^{-3}A^{-1}\right]$

(c) $\left[ML^2T^{-2}A^{-2}\right]$ (d) $\left[ML^2T^{-3}A^{-2}\right]$

JEE Main-26.06.2022, Shift-II

Ans. (c) : We know that, mutual inductance $L = \dfrac{\phi}{I}$

Dimension of $\phi = [ML^2T^{-2}A^{-1}]$

Dimension of $L = \dfrac{[ML^2T^{-2}A^{-1}]}{[A]}$

Dimension of $L = [ML^2T^{-2}A^{-2}]$

143. Identify the pair of physical quantities which have different dimensions

(a) Wave number and Rydberg's constant

(b) Stress and Coefficient of elasticity

(c) Coercivity and Magnetisation

(d) Specific heat capacity and Latent heat

JEE Main-24.06.2022, Shift-I

Ans. (d) Dimensional formula of specific heat capacity,

$C = [L^2T^{-2}\theta^{-1}]$

Dimensional formula of latent heat,

$L = [L^2T^{-2}]$

144. Identify the pair of physical quantities that have same dimensions:

(a) Velocity gradient and decay constant

(b) wien's constant and Stefan constant

(c) angular frequency and angular momentum

(d) wave number and Avogadro number

JEE Main-24.06.2022, Shift-II

Ans. (a) : Dimensional formula of velocity gradient and decay constant is same and it is given as $[M^0L^0T^{-1}]$.

145. If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula coefficient of viscosity is:

(a) $[P\,A^{-1}\,T^{0}]$ (b) $[P\,A\,T^{-1}]$

(c) $[P\,A^{-1}\,T]$ (d) $[P\,A^{-1}\,T^{-1}]$

JEE Main-25.07.2022, Shift-I

Ans. (a) : $[PA^{-1}T^0]$

We know,

Coefficient of viscosity = Pascal × second

$$P^xA^yT^z = [M^1L^{-1}T^{-1}]$$

$$[M^1L^1T^{-1}]^x\,[L^2]^y\,[T^1]^z = [M^1L^{-1}T^{-1}]$$

$$m^x\quad L^{x+2y}\;T^{-x+z} = M^1L^{-1}\,T^{-1}$$

Comparing the above equation,

$$x = 1,$$

$$x + 2y = -1$$

$$y = -1$$

$$z = 0$$

Coefficient of viscosity $= [P^1A^{-1}T^0]$

146. Which of the following physical quantities have the same dimensions?

(a) Electric displacement $(\vec{D})$ and surface charge density

(b) Displacement current and electric field

(c) Current density and surface charge density

(d) Electric Potential and energy

JEE Main-25.07.2022, Shift-I

Ans. (a) : We know,

Electric displacement $(\vec{D}) = q_0\,\vec{E}$

$$[D] = \left[q_0\,\frac{\sigma}{q_0}\right]$$

$$[D] = [\sigma]$$

From above, we can say Electric displacement $(\vec{D})$ is equal to surface charge density (σ).

147. The dimensional formula of emissivity of a body is

(a) $[M^1L^0T^{-3}]$ (b) $[M^1L^2T^{-3}]$

(c) $[M^0L^0T^0]$ (d) $[M^1L^2T^{-2}]$

AP EAPCET-12.07.2022, Shift-II

Ans. (c) : Emissivity can be defined as the ratio of the emissive power of body temperature and emissive power of the black body at same temperature. So, it is dimensionless formula which dimension is $\left[M^0L^0T^0\right]$

148. The energy E of a system is function of time t and is given by $E(t) = \alpha t - \beta t^3$ where α and β are constants. The dimensions of α and β are

(a) $\left[ML^2T^{-1}\right]$and$\left[ML^2T\right]$

(b) $\left[LT^{-1}\right]$and$\left[LT\right]$

(c) $\left[ML^2T^{-3}\right]$and$\left[ML^2T^{-5}\right]$

(d) $\left[MLT^{-1}\right]$and$\left[MLT\right]$

AP EAMCET-05.07.2022, Shift-I

Ans. (c) : $E(t) = \alpha t - \beta t^3$

By the principle of dimensional homogeneity.

Dimension of Energy = dimension of αt = dimension of βt^3

So, $[E] = [\alpha t]$

$$ML^2T^{-2} = [\alpha]\,[T]$$

$$[\alpha] = \frac{M^1L^2T^{-2}}{[T]}$$

$$[\alpha] = \left[ML^2T^{-3}\right]$$

and $[E] = [\beta t^3]$

$$\left[ML^2T^{-2}\right] = \beta[T^3]$$

$$[\beta] = \frac{\left[ML^2T^{-2}\right]}{\left[T^3\right]}$$

$$[\beta] = \left[ML^2T^{-5}\right]$$

So, the dimension of $[\alpha]$ and $[\beta]$ are $\left[ML^2T^{-3}\right]$and $\left[ML^2T^{-5}\right]$

@apna_pdf

149. If the dimension of (Angle × Force × Length) is $M^{n_1}\ L^{n_2}\ T^{n_3}$ then the value of (n_1, n_2, n_3) is

(a) (1, 1, –1) (b) (1. 2, –2)
(c) (1, 1, 1) (d) (1, 2, 2)

AP EAMCET-12.07.2022, Shift-I

Ans. (b) : [Angle] × [Force] × [Length] = $M^{n_1} \times L^{n_2} \times T^{n_3}$

the dimension of

Angle = $[M^\circ L^\circ T^\circ]$
Force = $[M^1L^1T^{-2}]$
Length = $[L^1]$

$[M^\circ L^\circ T^\circ] \times [M^1L^1T^{-2}] \times [L^1] = M^{n_1} \times L^{n_2} \times T^{n_3}$

$[M^1L^2T^{-2}] = [M^{n_1}\ L^{n_2}\ T^{n_3}]$

Comparing on both side, we get

$n_1 = 1, n_2 = 2, n_3 = -2$

150. If the dimensional formula of '(Energy × speed)' is $[M^aL^bT^C]$ then a, b and c are.

(a) (1,3,–3) (b) (1,2,3)
(c) (1,2,3) (d) (1,3,–2)

AP EAMCET-05.07.2022, Shift-II

Ans. (a) : Given that,

Dimensional formula of (Energy × Speed) = $[M^aL^bT^C]$

Dimension (Energy) = $M^1L^2T^{-2}$
Dimension (Speed) = L^1T^{-1}

$\therefore \quad [M^1L^2T^{-2}] \times [L^1T^{-1}] = [M^aL^bT^C]$

$[M^1L^3T^{-3}] = [M^aL^bT^C]$

On comparing both side we get,

a = 1
b = 3
c = –3

Thus (a, b, c) = (1, 3, –3)

151. The work done by a gas molecule in an isolated system is given by, $W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$ where x is the displacement, k is the Boltzmann constant and T is the temperature, α and β are constants. Then, the dimensions of β will be

(a) $\left[M^2LT^2\right]$ (b) $\left[M^0LT^0\right]$
(c) $\left[MLT^{-2}\right]$ (d) $\left[ML^2T^{-2}\right]$

JEE Main-24.02.2021, Shift-I

Ans. (c) : Given,

$$W = \alpha\beta^2 e^{\frac{-x^2}{\alpha kT}}$$

As we know, exponential terms are always dimensionless

So, dimension of $\left(\frac{-x^2}{\alpha kT}\right) = \left[M^0L^0T^0\right]$

Here, dimension of kT is equal to the dimension of energy = $M^1L^2T^{-2}$

$$\frac{\left[L^2\right]}{\left[\alpha\right]\left[ML^2T^{-2}\right]} = \left[M^0L^0T^0\right]$$

$$\left[\alpha\right] = \left[M^{-1}L^0T^2\right]$$

Now, From the given equation, we have dimension of W = dimension of α × dimension of β^2

$$\text{Dimension of } \beta = \sqrt{\frac{\text{dimension of w}}{\text{dimension of } \alpha}}$$

$$= \sqrt{\frac{\left[ML^2T^{-2}\right]}{M^{-1}L^0T^2}}$$

$$= \sqrt{M^2L^2T^{-4}}$$

Dimension of β = $[MLT^{-2}]$

152. In a typical combustion engine, the work done by a gas molecule is given $W = \alpha^2\beta e^{\frac{-\beta x^2}{kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. If α and β are constants, dimensions of α will be

(a) $\left[MLT^{-2}\right]$ (b) $\left[M^0LT^0\right]$
(c) $\left[M^2LT^{-2}\right]$ (d) $\left[MLT^{-1}\right]$

JEE Main-26.02.2021, Shift-I

Ans. (b) : kT has dimension of energy.

Exponential terms are always dimensionless.

So, $\frac{\beta x^2}{kT}$ is dimensionless

i.e. $\left[\frac{\beta x^2}{kT}\right] = \left[M^0L^0T^0\right]$

$$\frac{[\beta][L]^2}{\left[ML^2T^{-2}\right]} = \left[M^0L^0T^0\right]$$

$$[\beta]\left[L^2\right] = \left[ML^2T^{-2}\right]$$

$$[\beta] = \left[MT^{-2}\right]$$

$\alpha^2\beta$ has dimension of work

$$\left[\alpha^2\right]\left[MT^{-2}\right] = \left[ML^2T^{-2}\right]$$

$$\left[\alpha^2\right] = \frac{\left[ML^2T^{-2}\right]}{\left[MT^{-2}\right]}$$

$$\alpha = \sqrt{M^0L^2T^0}$$

$$\alpha = \left[M^0LT^0\right]$$

153. If force (F), length (L) and time (T) are taken as the fundamental quantities. Then what will be the dimension of density?

(a) $\left[FL^{-4}T^2\right]$ (b) $\left[FL^{-3}T^2\right]$
(c) $\left[FL^{-5}T^2\right]$ (d) $\left[FL^{-3}T^3\right]$

JEE Main-27.08.2021, Shift-II

@apna_pdf

Ans. (a) : As we know that,
Force = mass × acceleration

$$\text{mass} = \frac{\text{Force}}{\text{acceleration}}$$

$$\text{dimension of mass} = \frac{[F]}{[LT^{-2}]}$$

dimension of mass (m) = $[FL^{-1}T^2]$
Now,

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{Dimension of density} = \frac{[FL^{-1}T^2]}{[L^3]}$$

$$= [FL^{-4}T^2]$$

154. Which of the following is not a dimensionless quantity ?

(a) Relative magnetic permeability (μ_r)
(b) Power factor
(c) Permeability of free space (μ_0)
(d) Quality factor

JEE Main-27.08.2021, Shift-I

Ans. (c) : (a) Relative magnetic permeability (μ_r) = –1 as $\mu_r = \frac{\mu}{\mu_m}$ (Where, μ_r is constant and it is dimensionless)

(b) Power factor is an indication of the relative phase of the power line voltage and power line current. It ranges from 0 to 1. As it is a ratio. So, it has no dimension.

(c) Permeability of free space (μ_0) = $\frac{2\pi \times \text{force} \times \text{distance}}{\text{current} \times \text{current} \times \text{length}}$

$$= \frac{[MLT^{-2}][L]}{[A][A][L]} = [MLT^{-2}A^{-2}]$$

(d) Quality factor (Q) = $\frac{\text{Energy stored}}{\text{Energy dissipated per cycle}}$

So, Q is unit less and dimensionless.

155. Match List-I with List-II.

	List-I		List-II
A.	Magnetic induction	**1.**	$[ML^2T^{-2}A^{-1}]$
B.	Magnetic flux	**2.**	$[ML^{-1}A]$
C.	Magnetic permeability	**3.**	$[MT^{-2}A^{-1}]$
D.	Magnetisation	**4.**	$[MLT^{-2}A^{-2}]$

Choose the most appropriate answer from the options given below.

	A	B	C	D		A	B	C	D
(a)	2	4	1	3	(b)	2	1	4	3
(c)	3	2	4	1	(d)	3	1	4	2

JEE Main-26.08.2021, Shift-II

Ans. (d) : Magnetic induction → $[MT^{-2}A^{-1}]$
Magnetic flux → $[ML^2T^{-2}A^{-1}]$
Magnetic permeability → $[MLT^{-2}A^{-2}]$
Magnetisation → $[M^0L^{-1}A]$
Hence, correct option is (d)

156. If E,L,M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimension of P in the formula P =$EL^2M^{-5}G^{-2}$ is

(a) $[M^0L^1T^0]$
(b) $[M^{-1}L^{-1}T^2]$
(c) $[M^1L^1T^{-2}]$
(d) $[M^0L^0T^0]$

JEE Main-26.08.2021, Shift-I

Ans. (d) : Given,

$$P = \frac{EL^2}{M^5G^2} \qquad \ldots(i)$$

where, E → energy
L → angular momentum
M → mass
G → Gravitational constant

So, dimension of
Energy [E] = $[ML^2T^{-2}]$
Angular momentum [L] = $[ML^2T^{-1}]$
Gravitational constant [G] = $[M^{-1}L^3T^{-2}]$
Mass [M] = [M]

Substituting dimension of each quantity in equation (i)

$$[P] = \frac{[ML^2T^{-2}][ML^2T^{-1}]^2}{[M]^5[M^{-1}L^3T^{-2}]^2}$$

$$[P] = \frac{M^3L^6T^{-4}}{M^3L^6T^{-4}} \Rightarrow [P] = [M^0L^0T^0]$$

157. Which of the following equations is dimensionally incorrect ?
Where, t = time, h = height,
s = surface tension, θ= angle,
ρ= density, r = radius,
g = acceleration due to gravity,
V = volume , p= pressure, W = work done, τ = torque, ε = permittivity,
E = electric field, J = current density,
L = length.

(a) $V = \frac{\pi\rho a^4}{8\eta L}$
(b) $h = \frac{2s\cos\theta}{\rho rg}$
(c) $J = \varepsilon\frac{\partial E}{\partial t}$
(d) $W = \tau\theta$

JEE Main-31.08.2021, Shift-I

Ans. (a) : dimension of volume [V] = $[L^3]$
dimension of $[\eta] = [ML^{-1}T^{-1}]$

$$\therefore \frac{\pi\rho a^4}{8\eta L} = \frac{[ML^{-3}].[L^4]}{[ML^{-1}T^{-1}].[L]}$$

$$[LT] \neq V = [L^3]$$

Hence, this expression is dimensionally incorrect

@apna_pdf

158. A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be

(a) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (b) $\frac{2T}{rJ}$

(c) $\frac{3T}{rJ}$ (d) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

JEE Main-26.02.2021, Shift-I

Ans. (d) : Let, R is the radius of bigger drop and r is the radius of smaller drop.

Water drops are combined to form a bigger drop.

So, volume of n smaller drops = volume of a bigger drop

$$n\times\frac{4}{3}\pi r^3=\frac{4}{3}\pi R^3$$

$$n=\left(\frac{R}{r}\right)^3$$

$\Delta u = T \times$ change in surface area

$\Delta u = T\,(n\times 4\pi r^2-4\pi R^2)$

$$\Delta u=4\pi T\left[\left(\frac{R}{r}\right)^3 r^2-R^2\right]$$

$$=4\pi T\left(\frac{R^3}{r}-R^2\right)$$

$$\text{Heat energy (H)}=\frac{\Delta u}{J}=\frac{4\pi T\left(\frac{R^3}{r}-R^2\right)}{J}$$

Now,

$$\text{Heat energy per unit volume }\left(\frac{H}{V}\right)=\frac{4\pi T\left(\frac{R^3}{r}-R^2\right)}{J\times\frac{4}{3}\pi R^3}$$

$$=\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$$

159. The dimensions of stopping potential is

(a) $[ML^{-1}T^{-2}A^3]$ (b) $[M^{-1}L^{-2}T^3A^2]$

(c) $[M^{-2}LT^{-3}A^{-1}]$ (d) $[ML^2T^{-3}A^{-1}]$

Assam CEE-2021

Ans. (d) : $\text{Electrical Potential}=\frac{\text{Potential Energy}}{\text{Charge}}$

$$[V]=\frac{[E_p]}{[Q]}$$

$$=\frac{[ML^2T^{-2}]}{[AT]}$$

$$=[ML^2T^{-3}A^{-1}]$$

160. In the expression $P=\frac{a-t^2}{bx}$, P is pressure, t is time and x is the distance. The dimension of $\frac{a}{b}$ will be.

(a) $[LT^2]$ (b) $[MT^{-2}]$

(c) $[ML^2T^{-4}]$ (d) $[M^2LT^{-2}]$

Tripura-2021

Ans. (b) : Given expression $P=\frac{a-t^2}{bx}$

Where,

t = Time [T]

x = Distance [L]

P = Pressure $[ML^{-1}T^{-2}]$

$$P=\frac{a-t^2}{bx}$$

$Pbx = a - t^2$

$Pbx + t^2 = a$

Both side dividing by "b"

$$\frac{Pbx}{b}+\frac{t^2}{b}=\frac{a}{b}$$

$$Px+\frac{t^2}{b}=\frac{a}{b}$$

So, dimension of $\left[\frac{a}{b}\right]=Px=[ML^{-1}T^{-2}]\,[L]=[MT^{-2}]$

161. The force is given in terms of time t and displacement x by the equation

F = A cos Bx + C sin Dt

The dimensional formula of $\frac{AD}{B}$ is

(a) $[M^0LT^{-1}]$ (b) $[ML^2T^{-3}]$

(c) $[M^1L^1T^{-2}]$ (d) $[M^2L^2T^{-3}]$

JEE Main-25.07.2021, Shift-II

Ans. (b) : Given that,

F = A Cos Bx + C Sin Dt

$Bx = M^0L^0T^0$

$[B][L] = M^0L^0T^0$

$[B] = [L^{-1}]$ ...(1)

And, $Dt = M^0L^0T^0$

$[D] = [T^{-1}]$ ...(2)

And, $[A] = [C] = [MLT^{-2}]$...(3)

From equation (1), (2), (3)

$$\text{So, }\frac{AD}{B}=\frac{[MLT^{-2}][T^{-1}]}{[L^{-1}]}$$

$$\boxed{\frac{AD}{B}=[ML^2T^{-3}]}$$

@apna_pdf

162. Which of the following pairs of physical quantities possess same dimension?
(a) Force and surface tension
(b) Frequency and velocity gradient
(c) Angular speed and solid angle
(d) Stefan's constant and Plank's constant

AP EAMCET-24.08.2021, Shift-I

Ans. (b) : Velocity gradient is variation in velocity among the adjacent layers of the fluid

$$\therefore \text{ Velocity gradient} = \frac{\Delta V}{\Delta x} = \frac{\text{meter}}{\text{second}} \times \frac{1}{\text{meter}}$$

$$\frac{\Delta V}{\Delta x} = \frac{1}{\text{second}}$$

$\therefore$ Dimension of velocity gradient is $[M^0L^0T^{-1}]$, which is same as that of Frequency.
So option 'b' is correct.

163. Match List-I with List-II

List-I	List-II
A. h(Planck's constant)	1. $[MLT^{-1}]$
B. E (kinetic energy)	2. $[ML^2T^{-1}]$
C. V (electric potential)	3. $[ML^2T^{-2}]$
D. P (linear momentum)	4. $[ML^2I^{-1}T^{-3}]$

Choose the correct answer from the options given below.

	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	2	3	4	1
(c)	1	2	4	3	(d)	3	2	4	1

JEE Main-25.02.2021, Shift-I

Ans. (b) :

List-I	List-II
A. (Planck's constant)h	2. $[ML^2T^{-1}]$
B. (Kinetic energy)E	3. $[ML^2T^{-2}]$
C. (electric potential)v	4. $[ML^2T^{-3}I^{-1}]$
D. (linear momentum)p	1. $[MLT^{-1}]$

164. The time dependence of a physical quantity p is given by $P = P_o\, e^{-\alpha t^2}$, where a is a constant and t is the time. The constant "a"
(a) is dimensionless
(b) has dimensions $[T^{-2}]$
(c) has dimensions $[T^2]$
(d) has dimensions of p

CG PET-2021

Ans. (b) : $p = p_0\, e^{-\alpha t^2}$

$$[at^2] = [M^0L^0T^0]$$

$$[a] = \frac{1}{[t^2]}$$

$$[a] = [t^{-2}] = [T^{-2}]$$

165. Consider an expression QV = KPTL$^\alpha$ where V,P,T,L are volume, pressure, time and length respectively. The quantity [Q] has dimension $[ML^{-1}T^{-1}]$. K is dimensionless constant. The value of integer α is:
(a) 2
(b) –2
(c) 3
(d) –1

TS EAMCET 05.08.2021, Shift-I

Ans. (c) :
Consider an expression, $QV = KPTL^\alpha$ ...(i)
Where V = volume, P = Pressure, T = Time, L = Length
Given, the dimension of

$[Q] = [ML^{-1}T^{-1}]$
K = dimensionless constant

Find value of integer α.

By eq. (i), $Q = \dfrac{KPTL^\alpha}{V}$

$\because P = \dfrac{F}{A}$, then dimension of $[P] = \dfrac{[MLT^{-2}]}{[L^2]}$
$= [ML^{-1}T^{-2}]$

$$[Q] = K\frac{[P][T][L^\alpha]}{[V]}$$

$$= \frac{[ML^{-1}T^{-2}][T][L^\alpha]}{[L^3]} \qquad \text{Given that } \{\because [Q] = [ML^{-1}T^{-1}]\}$$

$ML^{-1}T^{-1} = ML^{-1-3+\alpha}\, T^{-2+1}$
$ML^{-1}T^{-1} = ML^{-4+\alpha}\, T^{-1}$
So, $L^{-1} = L^{-4+\alpha}$
then, $-1 = -4 + \alpha$ $\{\therefore \text{base same, power same}\}$
$\alpha = -1 + 4$
$\alpha = 3$

166. If ε_0 and μ_0 represent of permittivity and permeability of free space respectively. Then the dimension of the product $\varepsilon_0\, \mu_0$ is:
(a) $[M^0L^{-2}T^2]$
(b) $[M^0L^2T^{-2}]$
(c) $[M^0LT^{-1}]$
(d) $[M^0L^{-1}T]$

TS EAMCET 05.08.2021, Shift-II

Ans. (a) : Dimension of $\varepsilon_0 = [M^{-1}L^{-3}T^4A^2]$

Dimension of $\mu_0 = [MLT^{-2}A^{-2}]$

Then, dimension of $\varepsilon_0\mu_0$ = dimension of ε_0 × dimension of μ_0

$$= [M^{-1}L^{-3}T^4A^2] \times [MLT^{-2}A^{-2}]$$

$$= [M^{-1+1}L^{-3+1}T^{4-2}A^{2-2}] = [M^0L^{-2}T^2]$$

Dimension of $\varepsilon_0\mu_0 = [M^0L^{-2}T^2]$

167. The dimensions of σb^4 where 'σ' is Stefan's constant and 'b' is Wien's constant are
(a) $[M^0L^0T^0]$
(b) $[ML^4T^{-3}]$
(c) $[ML^{-2}T]$
(d) $[ML^6T^{-3}]$

TS EAMCET 04.08.2021, Shift-I

@apna_pdf

Ans. (b) : $\lambda_m T = b$

∴ $b^4 = \lambda_m^4 T^4$

$$\frac{\text{Energy}}{\text{Area}\times\text{Time}} = \sigma T^4$$

⇒ $$\sigma = \frac{\text{Energy}}{(\text{Area}\times\text{Time})T^4}$$

∴ $$\sigma b^4 = \left[\frac{\text{Energy}}{(\text{Area}\times\text{Time})T^4}\right]\lambda_m^4 T^4$$

$$= \frac{[ML^2T^{-2}]}{[L^2]\times[T]}\times[L^4] = \frac{[ML^{(2+4)}T^{-2-1}]}{[L^2]}$$

$$= [ML^{6-2}T^{-3}]$$

$$\sigma b^4 = [ML^4T^{-3}]$$

168. If momentum (P), area (A) and time (T) are taken to be the fundamental quantities then the dimensional formula for power is

(a) $\left[P^{\frac{1}{2}}AT^{-1}\right]$ (b) $\left[P^2AT^{-2}\right]$

(c) $\left[PA^{\frac{1}{2}}T^{-2}\right]$ (d) $\left[PA^{-1}T^{-2}\right]$

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (c) : From the dimensional relations:

Power = $k P^a A^b T^c$

Substituting the dimensions of the quantities,

$$[ML^2T^{-3}] = [ML^1T^{-1}]^a[L^2]^b[T]^c$$

$$= [M^aL^{a+2b}T^{-a+c}]$$

Comparing the dimensions:-

$a = 1$, $a + 2b = 2$, $-a + c = -3$

On solving the equations,

$a = 1$, $b = \frac{1}{2}$, $c = -2$

So, Power can be represented as:–

Power $= \left[PA^{1/2}T^{-2}\right]$

169. Which quantity among the following has neither units nor dimensions?

(a) Relative velocity (b) Relative density

(c) Angle (d) Energy

AP EAMCET-25.08.2021, Shift-II

Ans. (b) : Relative density is the ratio of two like quantities. Therefore, it has neither unit nor dimensions.

170. Dimensions of $\in_0 \frac{d\phi_\in}{dt}$ are same as that of (symbols have their usual meanings) ______

(a) Potential (b) Current

(c) Charge (d) Capacitance

AP EAMCET-03.09.2021, Shift-I

Ans. (b) : Dimensions of $\in_o \frac{d\phi_E}{dt}$ are same as that of current,

$$i = \in_o \frac{d\phi_E}{dt} \qquad \left[\because \phi = \frac{q}{\in_o}\right]$$

$$= \frac{\in_o \frac{q}{\in_o}}{[T]}$$

$$= \frac{[AT]}{[T]}$$

$$= [A]$$

Hence, A is unit of current.

171. If the energy $E = G^p h^q c^r$, where 'G' is the universal gravitational constant, 'c' is the velocity of light in vacuum and 'h' is Planck's constant. The values of p,q & r are respectively ______

(a) $\frac{-1}{2}, \frac{1}{2} \& \frac{5}{2}$ (b) $\frac{1}{2}, \frac{-1}{2} \& \frac{-5}{2}$

(c) $\frac{1}{2}, \frac{-1}{2} \& \frac{3}{2}$ (d) $\frac{1}{2}, \frac{-1}{2} \& \frac{-3}{2}$

AP EAMCET-06.09.2021, Shift-I

Ans. (a) : The given energy formula,

$E = G^p h^q c^r$

Writing the dimensions of every quantity,

$[ML^2T^{-2}] = [M^{-1}L^3T^{-2}]^p\,[ML^2T^{-1}]^q\,[LT^{-1}]^r$

$[ML^2T^{-2}] = [M^{-p+q}\,L^{3p+2q+r}\,T^{-2p-q-r}]$

Applying the principle of homogeneity, we get

$-p + q = 1$ ...(i)

$3p + 2q + r = 2$ ...(ii)

$-2p - q - r = -2$ ...(iii)

Adding (ii) and (iii)

$p + q = 0$ ...(iv)

solving (i) and (iv)

$q = 1/2$

from (i), $p = -1/2$

put the value of p and q in equation (ii)

$r = 5/2$

172. If E and G respectively denote energy and gravitational constant. Then $\frac{E}{G}$ has the dimensions of

(a) $[M^2]\,[L^{-1}]\,[T^0]$ (b) $[M]\,[L^{-1}]\,[T^{-1}]$

(c) $[M]\,[L^0]\,[T^0]$ (d) $[M^2]\,[L^{-2}]\,[T^{-1}]$

[NEET 2021]

Ans. (a)

Energy (E) $= \frac{1}{2}mv^2$

Dimension of E = $[ML^2T^{-2}]$

and gravitational constant (G) $= \frac{Fr^2}{m_1m_2}$

@apna_pdf

$$G = \frac{[MLT^{-2}][L^2]}{[M^2]}$$

$$G = [M^{-1}L^3T^{-2}]$$

Now,

Dimension of $\frac{E}{G} = \frac{[ML^2T^{-2}]}{[M^{-1}L^3T^{-2}]}$

$$\frac{E}{G} = [M^2L^{-1}T^0]$$

173. If E and E_0 represent the energies, t and t_0 represent the times, then which of the following is dimensionally correct relation?

(a) $E = E_0 e^{-t}$ (b) $E = E_0 t_0\, e^{-t/\,t}{}_0$

(c) $E = E_0 t_0 e^{-t^2}$ (d) $E = E_0 e^{-t/t_0}$

TS-EAMCET-09.09.2020, Shift-1

Ans. (d): If E and E_0 represent the energies, t and t_0 represent the times, then the relation is

$$E = E_0 e^{-t/t_0}$$

174. The dimension of angular momentum in mass (M), length (L) and time (T) is

(a) $[MLT^{-1}]$ (b) $[ML^{-1}T^{-1}]$

(c) $[ML^2T^{-1}]$ (d) $[ML^{-1}T^{-2}]$

TS-EAMCET.11.09.2020, Shift-2

Ans. (c) : We know that,

Angular momentum = Angular velocity × Moment of Inertia

Dimension of angular momentum $= [T^{-1}]\,[ML^2]$

$= [ML^2T^{-1}]$

175. The dimension of $\frac{E^2}{\mu_0}$ in mass (M), length (L) and time (T) is (E = electric field, μ_0 = permeability of free space)

(a) $[M^2L^3T^{-2}A^2]$ (b) $[MLT^{-4}]$

(c) $[ML^3T^{-2}]$ (d) $[ML^4T^{-4}]$

TS-EAMCET-14.09.2020, Shift-1

Ans. (b) : Dimension of electric field (E) = $[MLT^{-3}I^{-1}]$

Dimension of Permeability (μ_0) = $[MLT^{-2}I^{-2}]$

So,

Dimension of $\frac{E^2}{\mu_0} = \frac{[MLT^{-3}I^{-1}]^2}{[MLT^{-2}I^{-2}]} = \frac{[M^2L^2T^{-6}I^{-2}]}{[MLT^{-2}I^{-2}]}$

$= [MLT^{-4}]$

176. Due to an explosion underneath water, a bubble started oscillating. If this oscillation has time period T, which is proportional to $P^{\alpha}S^{\beta}E^{\gamma}$, where P is static pressure, S is density of water and E is total energy of explosion. Determine α, β and γ.

(a) $\alpha = -\frac{3}{2}, \beta = \frac{1}{3}, \gamma = -\frac{5}{6}$

(b) $\alpha = -\frac{5}{6}, \beta = \frac{1}{2}, \gamma = \frac{1}{3}$

(c) $\alpha = \frac{1}{2}, \beta = -\frac{5}{6}, \gamma = \frac{7}{4}$

(d) $\alpha = \frac{1}{3}, \beta = \frac{3}{2}, \gamma = \frac{4}{3}$

TS-EAMCET-10.09.2020, Shift-1

Ans. (b) : Given,

$T \propto P^{\alpha} S^{\beta} E^{\gamma}$

$T = k\, P^{\alpha} S^{\beta} E^{\gamma}$ $(\because k = \text{Constant})$

Using dimensional balance method.

$[M^0L^0T^1] = [M^1L^{-1}T^{-2}]^{\alpha}[ML^{-3}T^0]^{\beta}[M^1L^2T^{-2}]^{\gamma}$

$[M^0L^0T^1] = [M^{\alpha+\beta+\gamma}L^{-\alpha-3\beta+2\gamma}T^{-2\alpha-2\gamma}]$

Comparison of power in both side

$\alpha + \beta + \gamma = 0$ ... (i)

$-\alpha - 3\beta + 2\gamma = 0$ ...(ii)

$-2\alpha - 2\gamma = 1,\ \alpha + \gamma = \frac{-1}{2}$ ...(iii)

From equation (i), (ii) and (iii) we get,

$\alpha = \frac{-5}{6}, \beta = \frac{1}{2}, \gamma = \frac{1}{3}$

177. A quantity f is given by $f = \sqrt{hc^5/G}$, where c is speed of light, G universal gravitational constant and h is the Planck's constant. Dimension of f is that of

(a) area (b) volume

(c) momentum (d) energy

JEE Main-09.01.2020, Shift-I

Ans. (d) : Given,

Speed of light (c) = $[LT^{-1}]$

Gravitational constant (G) = $[M^{-1}L^3T^{-2}]$

Planck's constant (h) = $[ML^2T^{-1}]$

$$[F] = \sqrt{\frac{hc^5}{G}}$$

$$[F] = \sqrt{\frac{[ML^2T^{-1}][L^1T^{-1}]^5}{[M^{-1}L^3T^{-2}]}} \Rightarrow [F] = \sqrt{\frac{[ML^2T^{-1}][L^5T^{-5}]}{[M^{-1}L^3T^{-2}]}}$$

$$[F] = \sqrt{[M^2L^4T^{-4}]} \Rightarrow [F] = [ML^2T^{-2}]$$

178. Dimensional formula for thermal conductivity is (Here, K denotes the temperature)

(a) $[MLT^{-2}K]$ (b) $[MLT^{-2}K^{-2}]$

(c) $[MLT^{-3}K^{-1}]$ (d) $[MLT^{-3}K]$

JEE Main-04.09.2020, Shift-I

Ans. (c) : Thermal conductivity, we can find the dimension formula using the equation.

$$\frac{\Delta Q}{\Delta t} = -KA\frac{\Delta T}{\Delta x}$$

Therefore, the dimension of thermal conductivity

$$K = \frac{-\Delta Q.\Delta x}{\Delta t.\Delta T} \times \frac{1}{A}$$

@apna_pdf

$$=\frac{\text{energy}}{\text{time}}.\frac{\text{length}}{\text{temperature}}\times\frac{1}{\text{Area}}$$

$$=\frac{[ML^2T^{-2}]}{[T]}\times\frac{[L]}{[K]}\times\frac{1}{[L^2]}=\frac{[ML^3T^{-2}]}{[TK.L^2]}$$

$$=[MLT^{-3}K^{-1}]$$

179. The physical quantities that have the same dimension are

(a) Couple of force and work

(b) Force and power

(c) Latent heat and specific

(d) Work and power

AP EAMCET-07.10.2020, Shift-I

Ans. (a) : The dimension of couple of force is $[ML^2T^{-2}]$.

The dimension of Work is $[ML^2T^{-2}]$.

The dimension of Force is $[M^1L^1T^{-2}]$.

The dimension of Power is $[M^1L^2T^3]$.

The dimension of Latent heat is $[M^0L^2T^{-2}]$.

The dimension of specific heat is $[M^0L^2T^{-2}K^{-1}]$.

So, the physical quantities that have the same dimension are 'couple of force and work'.

180. A quantity x is given by $x=\frac{IFv^2}{WL^4}$ where, I is moment of inertia, F is force, v is velocity, w is work and L is length. The dimensional formula for x is same as that of

(a) Planck's constant

(b) force constant

(c) coefficient of viscosity

(d) energy density

JEE Main-04.09.2020, Shift-II

Ans. (d) : Given,

$$x=\frac{IFv^2}{WL^4}$$

$$[x]=\frac{[ML^2]\times[MLT^{-2}]\times[L^2T^{-2}]}{[ML^2T^{-2}][L^4]}$$

$$[x]=[ML^{-1}T^{-2}]$$

$$\text{Energy density}=\frac{\text{Energy}}{\text{Volume}}=\frac{[ML^2T^{-2}]}{[L^3]}=[ML^{-1}T^{-2}]$$

So, dimensional formula of x is same as energy density.

181. The quantities $x=\frac{1}{\sqrt{\mu_0\varepsilon_0}}, y=\frac{E}{B}$ and $z=\frac{L}{CR}$ are defined, where C is capacitance, R is resistance, L is length, E is electric field, B is magnetic field, ε_0 is free space permittivity and μ_0 is permeability, respectively. Then,

(a) x, y and z have the same dimension

(b) Only x and z have the same dimension

(c) Only x and y have the same dimension

(d) Only y and z have the same dimension

JEE Main-05.09.2020, Shift-II

Ans. (a) : x, y and z have same dimension.

We know,

$$x=\frac{1}{\sqrt{\mu_0\varepsilon_0}}=[LT^{-1}]$$

$$y=\frac{E}{B}=[LT^{-1}]$$

$$z=\frac{L}{CR}=[LT^{-1}]$$

So, x, y, z have same dimension.

182. The dimension of $\frac{B^2}{2\mu_o}$, where B is magnetic field and μ_0 is the magnetic permeability of vacuum, is

(a) $[ML^{-1}T^{-2}]$

(b) $[MLT^{-2}]$

(c) $[ML^2T^{-1}]$

(d) $[ML^2T^{-2}]$

JEE Main-07.01.2020, Shift-II

Ans. (a) : We know,

$$\text{Energy density }=\frac{B^2}{2\mu_0}$$

$$\text{Energy density }=\frac{\text{Energy}}{\text{Volume}}$$

$$E=\frac{\text{Force}\times\text{Displacement}}{(\text{Dimension})^3}$$

Dimensional formula of energy density,

$$E=[ML^{-1}T^{-2}]$$

183. The dimension of stopping potential V_0 in photoelectric effect in units of Planck's constant h, speed of light c and gravitational constant G and ampere A is

(a) $[h^{-2/3}c^{-1/3}G^{4/3}A^{-1}]$

(b) $[h^0G^{-1}c^5A^{-1}]$

(c) $[h^2G^{3/2}c^{1/3}A^{-1}]$

(d) $[h^{2/3}c^{5/3}G^{1/3}A^{-1}]$

JEE Main-08.01.2020, Shift-I

Ans. (b) : We know,

$$V_0=[ML^2\,T^{-3}\,A^{-1}],\ h=[ML^2\,T^{-1}],$$

$$c=[L\,T^{-1}],G=[M^{-1}L^3\,T^{-2}],\ I=[A]$$

Then, dimensional formula of stopping potential is given as –

$$V_0=[h]^a\,[A]^b\,[G]^c\,[c]^d \quad \ldots\ldots\ldots\text{(i)}$$

$$[ML^2\,T^{-3}\,A^{-1}]=[ML^2\,T^{-1}]^a\,[A]^b\,[M^{-1}\,L^3\,T^{-2}]^c\,[LT^{-1}]^d$$

$$[ML^2\,T^{-3}\,A^{-1}]=[M^{a-c}\,L^{2a+3c+d}\,T^{-a-2c-d}\,A^b]$$

On comparing both side –

$$a-c=1,\ 2a+3c+d=2,\ -a-2c-d=-3,\ b=-1$$

Solving the above equations, we get –

$$a=0\ ,\ b=-1,\ c=-1,\ d=5$$

Putting the value of a, b, c, d in equation (i)–

Hence, $[V_0]=[K\,h^0\,c^5\,G^{-1}\,A^{-1}]$; K = 1

@apna_pdf

184. If momentum P, area A and time T are taken to be the fundamental quantities, then the dimensional formula for energy is

(a) $\left[P^2AT^{-2}\right]$ (b) $\left[PA^{-1}T^{-2}\right]$

(c) $\left[PA^{1/2}T^{-1}\right]$ (d) $\left[P^{1/2}AT^{-1}\right]$

JEE Main-02.09.2020, Shift-II

Ans. (c) : According the question energy is represented as –

$$E=[P]^a[A]^b[T]^c \text{ ...... (i)}$$

Dimensional formula of parameters given in the equation (i)

$$P=\left[MLT^{-1}\right], A=\left[L^2\right], T=[T], E=\left[ML^2T^{-2}\right]$$

Putting the above value in equation (i)

$$\left[ML^2T^{-2}\right]=\left[MLT^{-1}\right]^a\left[L^2\right]^b[T]^c$$

$$\left[ML^2T^{-2}\right]=\left[M^aL^{a+2b}T^{c-a}\right]$$

On comparing both side –

a = 1, a + 2b = 2, c – a = –2

Solving the above equation we get –

a = 1, b = ½, c = –1

Putting the value of a, b, c in equation (i)

$$[E]=[P]^1[A]^{1/2}[T]^{-1}$$

$$[E]=\left[P^1A^{1/2}T^{-1}\right]$$

185. Amount of solar energy received on the earth's surface per unit area per unit time is defined as solar constant. Dimensional formula of solar constant is

(a) $\left[MLT^{-2}\right]$ (b) $\left[ML^0T^{-3}\right]$

(c) $\left[M^2L^0T^{-1}\right]$ (d) $\left[ML^2T^{-2}\right]$

JEE Main-03.09.2020, Shift-II

Ans. (b) : According to question solar constant (K) is defined as amount of solar energy received on earth surface per unit area per unit time.

So,

$$\text{Solar constant (K)} = \frac{\text{Energy}}{\text{Area}\times\text{time}}$$

Dimensional formula of energy = $[ML^2T^{-2}]$

Dimensional formula of area = $[L^2]$

Dimensional formula of time = $[T]$

$$\text{Dimension of solar constant, K} = \frac{\left[ML^2T^{-2}\right]}{\left[L^2\right][T]}$$

$$K = [MT^{-3}]$$

∴ Dimensional formula of solar constant = $[ML^0T^{-3}]$

186. Which among the following has dimension of charge?

(a) $\varepsilon_0\, E/ds$ (b) $\varepsilon_0\, E.ds$

(c) $\frac{\mu_0}{\varepsilon_0}E.ds$ (d) $\frac{\varepsilon_0}{\mu_0}E.ds$

AP EAMCET (23.09.2020) Shift-I

Ans. (b) :

Gauss's Law $\phi_E=\frac{Q}{\varepsilon_o}$

Where, Q = Total charge

ε_0 = Electric constant

ϕ_ε = Electric flux

$$Eds=\frac{Q}{\varepsilon_o}$$

$$[Q]=[\varepsilon_o E.ds]$$

187. The dimensional formula of Polarization P is _____.

(a) $[L^{-2}A^{-1}T^1]$ (b) $[M^1L^{-2}T^1]$

(c) $[L^2A^{-1}T^1]$ (d) $[L^{-2}A^1T^1]$

GUJCET 2020

Ans. (d) : Polarization=$\frac{\text{Dipole moment}}{\text{Volume}}$

Dimension of polarization

$$=\left[\frac{qd}{L^3}\right](\text{dipole moment} = qd)$$

$$=[L^{-2}T^1A^1]$$

188. Suppose refractive index μ is given as $\mu = A + \frac{B}{\lambda^2}$ where A and B are constants and λ is wavelength, then dimension of B are same as that of

(a) Wavelength (b) volume

(c) Pressure (d) area

COMEDK 2020

Ans. (d) : As refractive index,

$$(\mu)=\frac{\text{velocity of light in vaccum}(c)}{\text{velocity of light in medium}}$$

Since, refractive index is ratio of velocity so it is dimension less quantity.

$$\mu = A+\frac{B}{\lambda^2}$$

So, dimensionally μ, A , and $\frac{B}{\lambda^2}$ are same,

$$[\mu]=[A]=\frac{[B]}{\left[\lambda^2\right]}$$

$$\frac{[B]}{\left[\lambda^2\right]}=\left[M^0L^0T^0\right]$$

$$[B]=\left[\lambda^2\right]=\left[L^2\right] \qquad (\because \lambda = \text{wavelength in meter})$$

Dimension of [B] is equal to $[\lambda^2]$ i.e. $[L^2]$ which represent the dimension of area.

189. Let 'σ' and 'b' be Stefan's constant and Wien's constant respectively, then dimensions of 'σb' are

(a) $L^1M^1T^3K^{-3}$ (b) $L^{-1}M^1T^{-3}K^{-3}$

(c) $L^1M^{-1}T^{-3}K^{-3}$ (d) $L^1M^1T^{-3}K^{-3}$

MHT-CET 2020

@apna_pdf

Ans. (d) : Here, σ = Stefan constant

b = Wien's constant

Dimensions of $[\sigma \times b]$

We know that,

$$\sigma = \frac{E}{T^4} = \frac{Q}{AtT^4} = \frac{ML^2T^{-2}}{L^2TK^4} = [MT^{-3}K^{-4}]$$

E = Heat energy per unit area per unit time.

From Wien's law–

$$\lambda = \frac{b}{T}$$

$$b = \lambda.T = [L.K]$$

Dimensions of $[\sigma \times b]$

$$= [MT^{-3}K^{-4} \times LK]$$

$$= [MLT^{-3}K^{-3}]$$

190. Which of the following expression has a dimensional formula different from others?

(a) $\frac{1}{2} \in_0 E^2$ f($\in_0$ permitivity of free space, E: electric field)

(b) hν (h: Plancks constant, ν: frequency)

(c) ρgh (ρ: density, g: acceleration due to gravity, h: height)

(d) $\frac{1}{2}\rho v^2$ (ρ: density, v: velocity)

UPSEE 2020

Ans. (b) :

(a) $\frac{1}{2} \in_0 E^2 = \frac{\text{Energy}}{\text{Volume}}$

Dimension of $\frac{1}{2} \in_0 E^2 = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

(b) $h\nu$ = Energy of photon

Dimension of $h\nu = ML^2T^{-2}$

(c) Dimension of $\rho gh = [ML^{-3}]\,[LT^{-2}]\,[L] = ML^{-1}T^{-2}$

(d) Dimension of $\frac{1}{2}\rho v^2 = [ML^{-3}][LT^{-1}]^2$

$$= [ML^{-1}T^{-2}]$$

So, dimension of $\frac{1}{2} \in_0 E$, ρgh and $\frac{1}{2}\rho v^2$ same

But $h\nu$ has different dimensional formula.

191. The force of interaction between two atoms is given by $F = \alpha\beta \exp\left(-\frac{x^2}{\alpha kT}\right)$; where x is the distance, k is the Boltzmann constant and T is temperature and α and β are two constants. The dimension of β is

(a) $\left[MLT^{-2}\right]$

(b) $\left[M^0L^2T^{-4}\right]$

(c) $\left[M^2LT^{-4}\right]$

(d) $\left[M^2L^2T^{-2}\right]$

JEE Main-11.01.2019, Shift-I

Ans. (c) : $[M^2LT^{-4}]$

We know,

$$F = \alpha\beta \exp\left(\frac{-x^2}{\alpha KT}\right)$$

In expression, there will be dimensionless.

$$\frac{\left[L^2\right]}{\alpha \times [ML^2T^{-2}\theta^{-1}] \times [\theta]} = \left[M^0L^0T^0\right]$$

$$= \frac{\left[L^2\right]}{\alpha \times \left[ML^2T^{-2}\right]} = \left[M^0L^0T^0\right]$$

$$\alpha = \left[M^{-1}T^{+2}\right]$$

Now,

$$F = \alpha\beta$$

$$[MLT^{-2}] = [M^{-1}T^2] \times [\beta]$$

$$\beta = [M^2LT^{-4}]$$

192. Which of the following combinations has the dimension of electrical resistance (ε_0 is the permittivity of vacuum and μ_0 is the permeability of vacuum) ?

(a) $\sqrt{\frac{\mu_o}{\varepsilon_o}}$

(b) $\frac{\mu_o}{\varepsilon_o}$

(c) $\sqrt{\frac{\varepsilon_o}{\mu_o}}$

(d) $\frac{\varepsilon_o}{\mu_o}$

JEE Main-12.04.2019, Shift-I

Ans. (a) : We know that,

$$V = IR \Rightarrow R = \frac{V}{I} = \frac{W/q}{I} = \frac{W}{qI}$$

Where, V = Voltage, I = current, R = resistance

W = workdone, q = charge

$$R = \frac{[ML^2T^{-2}]}{[A^2][T]} = [ML^2T^{-3}A^{-2}]$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2} = \varepsilon_0 = \frac{q_1q_2}{4\pi r^2F}$$

$$= \frac{I^2t^2}{[L^2][MLT^{-2}]} = \frac{[A^2][T^{-2}]}{[L^2][MLT^{-2}]}$$

$$\varepsilon_0 = [M^{-1}L^{-3}T^4A^2] \qquad ...(1)$$

$$c^2 = \frac{1}{\mu_0\varepsilon_0} \Rightarrow \mu_0 = \frac{1}{c^2\varepsilon_0}$$

$$\mu_0 = \frac{1}{[L^2T^{-2}][M^{-1}L^{-3}T^4A^2]}$$

$$\mu_0 = [M^1L^1T^{-2}A^{-2}] \qquad ...(2)$$

From eq^n (i) & eq^n (ii)

$$\frac{\varepsilon_0}{\mu_0} = \frac{[M^{-1}L^{-3}T^4A^2]}{[M^1L^1T^{-2}A^{-2}]} = [M^{-2}L^{-4}T^6A^4]$$

$$\frac{\varepsilon_0}{\mu_0} = [M^2L^4T^{-6}A^{-4}] \Rightarrow \sqrt{\frac{\mu_0}{\varepsilon_0}} = [ML^2T^{-3}A^{-2}]$$

So, option (a) is correct.

@apna_pdf

193. In SI units, the dimensions of $\sqrt{\frac{\varepsilon_o}{\mu_o}}$ is

(a) $\left[A^{-1}TML^3\right]$ (b) $\left[AT^2M^{-1}L^{-1}\right]$

(c) $\left[AT^{-3}ML^{3/2}\right]$ (d) $\left[A^2T^3M^{-1}L^{-2}\right]$

JEE Main-08.04.2019, Shift-I

Ans. (d) : We know that,

$$\varepsilon_0 = \frac{q^2}{Fr^2} = \frac{I^2t^2}{Fr^2} = \frac{[A^2.T^2]}{[MLT^{-2}L^2]}$$

$$= [M^{-1}L^{-3}T^4A^2]$$

$$\mu_0 = \frac{1}{c^2\varepsilon_0} = \frac{1}{[L^2T^{-2}][M^{-1}L^{-3}T^4A^2]}$$

$$\mu_0 = [MLT^{-2}A^{-2}]$$

The dimension of $= \sqrt{\frac{\varepsilon_0}{\mu_0}} = \sqrt{\frac{[M^{-1}L^{-3}T^4A^2]}{[MLT^{-2}A^{-2}]}}$

$$= \sqrt{[M^{-2}L^{-4}T^6A^4]}$$

$$= [M^{-1}L^{-2}T^3A^2]$$

194. The expression for the force is given by $b + \frac{c}{t^3}$ where 'b' and 'c' are some physical quantities and 't' is the time. Then the dimensions of 'c' are

(a) $[M^0LT]$ (b) $[MLT^{-1}]$

(c) $[MLT^{-2}]$ (d) $[MLT]$

TS EAMCET 08.05.2019, Shift-I

Ans. (d) :

Force = mass × acceleration

Or F = ma

$$F = b + \frac{c}{t^3}$$

$\because$ F = $[MLT^{-2}]$

The dimension of c are

$$F = \frac{c}{t^3}$$

$$c = F \times t^3$$

$$c = [MLT^{-2}] \times \left[T^3\right]$$

$$c = \left[MLT^1\right]$$

$$c = \left[MLT\right]$$

195. In form of G (universal gravitational constant), h (Planck constant) and c (speed of light), the time period will be proportional to

(a) $\sqrt{\frac{Gh}{c^5}}$ (b) $\sqrt{\frac{hc^5}{G}}$

(c) $\sqrt{\frac{c^3}{Gh}}$ (d) $\sqrt{\frac{Gh}{c^3}}$

JEE Main-09.01.2019, Shift-II

Ans. (a) : We know,

$$G = \frac{Fr^2}{m^2}, G = \left[M^{-1}L^3T^{-2}\right]$$

$$h = \left[ML^2T^{-1}\right], c = \left[LT^{-1}\right]$$

Now, time period is expressed as –

$$T = K\,G^x\,h^y\,c^z$$

$$[T] = [M^{-1}L^3T^{-2}]^x\,[ML^2T^{-1}]^y[LT^{-1}]^z$$

$$[M^0L^0T^1] = [M^{-x+y}L^{3x+2y+z}T^{-2x-y-z}]$$

Comparing the power in above equation,

$$-x + y = 0 \Rightarrow x = y$$

$$3x + 2y + z = 0 \Rightarrow 5x + z = 0$$

$$-2x - y - z = 1 \Rightarrow 3x + z = -1$$

On solving the above equation, we get–

$$x = \frac{1}{2}, y = \frac{1}{2}, z = \frac{-5}{2}$$

$$T = K\sqrt{\frac{Gh}{c^5}}$$

196. If surface tension (S), moment of inertia (I) and Planck's constant (h), were to be taken as the fundamental units, the dimensional formula for linear momentum would be

(a) $S^{1/2}I^{1/2}h^{-1}$ (b) $S^{3/2}I^{1/2}h^0$

(c) $S^{1/2}I^{1/2}h^0$ (d) $S^{1/2}I^{3/2}h^{-1}$

JEE Main-08.04.2019, Shift-II

Ans. (c) : Dimensional formula of linear momentum is expressed as –

$$P = KS^a\,I^b\,h^c \qquad \ldots\ldots. (i)$$

Where, K = dimensionless constant

Putting the dimensional formula of given parameters in equation (i)–

$$[MLT^{-1}] = [MT^{-2}]^a\,[ML^2]^b\,[ML^2T^{-1}]^c$$

$$[MLT^{-1}] = [M^{a+b+c}\,L^{2b+2c}\,T^{-2a-c}]$$

On comparing both side –

$$a + b + c = 1,\ 2b + 2c = 1,\ -2a - c = -1$$

Solving the above equation we get,

$$a = \frac{1}{2}, b = \frac{1}{2}, c = 0$$

Putting the value of a, b, c in equation (i)–

$$P = K\,S^{1/2}\,I^{1/2}\,h^0$$

197. In the formula X = 5YZ², X and Z have dimensions of capacitance and magnetic field, respectively. What are the dimensions of Y in SI units?

(a) $\left[M^{-1}L^{-2}T^4A^2\right]$

(b) $\left[M^{-2}L^0T^{-4}A^{-2}\right]$

(c) $\left[M^{-3}L^{-2}T^8A^4\right]$

(d) $\left[M^{-2}L^{-2}T^6A^3\right]$

JEE Main-10.04.2019, Shift-II

@apna_pdf

Ans. (c) : Given,

$X = 5YZ^2$

Where $[X] = [M^{-1} L^{-2} T^4 A^2]$

$[Z] = [M^1 T^{-2} A^{-1}]$

Now,

$$Y = \frac{X}{5Z^2}$$

$$Y = \frac{\left[M^{-1}L^{-2}T^4A^2\right]}{5\left[M^1T^{-2}A^{-1}\right]^2}$$

$$Y = \left[M^{-3}L^{-2}T^8A^4\right]$$

198. P, Q, R and S denote energy, mass, angular momentum and gravitational constant respectively, the quantity $\left[\frac{Q^5S^2}{PR^2}\right]$ has the dimensions of

(a) Mass (b) Length

(c) Time (d) Angle

AP EAMCET (Medical)-24.04.2019, Shift-I

Ans. (d) : Given,

Let quantity is x

So, $x = \left[\frac{Q^5S^2}{PR^2}\right]$ ....(i)

Where, P → energy

Q → mass

R → angular momentum

S → Gravitational constant

Dimension of ,

Energy $[P] = [ML^2T^{-2}]$

Mass $[Q] = [M]$

Angular momentum $[R] = [ML^2T^{-1}]$

Gravitational constant $[S] = [M^{-1}L^3T^{-2}]$

Substituting dimension of each quantity in equation (1)

$$[x] = \frac{[M]^5\left[M^{-1}L^3T^{-2}\right]^2}{\left[ML^2T^{-2}\right]\left[ML^2T^{-1}\right]^2}$$

$$= \frac{M^3L^6T^{-4}}{M^3L^6T^{-4}} = \left[M^0L^0T^0\right]$$

Angle is dimension less quantity

So, dimension formula of angle $= [M^0L^0T^0]$

199. If R, L, C, F, v, q, I and t represent resistance, inductance, capacitance, force, velocity. electric charge, electric current and time respectively, then which of the following will have same dimensions?

(A) $[I^2 R]$ (B) $\left[\frac{L}{Rt}\right]$

(C) $\left[\frac{q^2}{RC^2}\right]$ (D) $\left[\frac{Fv}{t}\right]$

(a) A & B (b) A & C

(c) B & D (d) A & D

AP EAMCET-23.04.2019, Shift-II

Ans. (b) :

(A) $I^2R = I^2 \times \frac{V}{I}$ $\left(\because R = \frac{V}{I}\right)$

$= V \times I$

$[I^2R] = [ML^2T^{-3}A^{-1}][A] = [ML^2T^{-3}]$

(B) $\frac{L}{Rt}$

We have formula for inductance is

$$L = \frac{V}{\frac{dI}{dt}}$$

$$[L] = \frac{\left[ML^2T^{-3}A^{-1}\right]}{\left[AT^{-1}\right]} = \left[ML^2T^{-2}A^{-2}\right]$$

$$\left[\frac{L}{Rt}\right] = \frac{\left[ML^2T^{-2}A^{-2}\right]}{\left[ML^2A^{-2}T^{-3}\right][T]}$$

$= [M^0L^0T^0]$

(C) $\frac{q^2}{RC^2}$

$$\left[\frac{q^2}{RC^2}\right] = \frac{\left[T^2A^2\right]}{\left[ML^2A^{-2}T^{-3}\right]\left[M^{-1}L^{-2}T^4A^2\right]^2}$$

$= [ML^2T^{-3}]$

(D) $\frac{Fv}{t}$

$$\left[\frac{Fv}{t}\right] = \frac{\left[M^1L^1T^{-2}\right]\left[LT^{-1}\right]}{[T]} = [ML^2T^{-4}]$$

So, A & C have same dimension.

200. If the velocity of light (C), gravitational constant (G) and Plank's constant (h) are chosen as fundamental units, the dimensions of time will be

(a) $C^{-3/2}G^2h^{-1/2}$ (b) $C^{-3/2}G^2h^2$

(c) $C^2G^{-2}h^{1/2}$ (d) $C^{-3/2}G^{1/2}h^{1/2}$

Assam CEE-2019

Ans. (d) : $T \propto C^xG^y h^z$ ……(i)

Dimension of

time $[t] = [T]$

light $[C] = [LT^{-1}]$

Gravitational constant $[G] = [M^{-1}L^3T^2]$

Plack constant $[h] = [ML^2T^{-1}]$

Putting value of each dimension in equation (i)

$[T] \propto [LT^{-1}]^x [M^{-1}L^3T^{-2}]^y [ML^2T^{-1}]^z$

$[M^0L^0T^1] \propto [M^{-y+z} L^{x+3y+2z} T^{-x-2y-z}]$

On comparing both side we get

$-y + z = 0$ ….. (ii)

$x + 3y + 2z = 0$ ….. (iii)

$-x - 2y - z = 1$ ….. (iv)

On solving equation (ii), (iii), (iv), we get

$$x = \frac{-3}{2},\ y = \frac{1}{2},\ z = \frac{1}{2}$$

Putting the value of x, y and z in equation (i), we get

$T \propto C^{-3/2} G^{1/2} h^{1/2}$

@apna_pdf

201. The dimensional formula of modulus of elasticity and its unit are

(a) $[ML^{-1}T^{-2}]$ and Pascal
(b) $[ML^{-2}T^{-1}]$ and Pascal
(c) $[ML^{-1}T^{-2}]$ and Poise
(d) $[ML^{-2}T^{-1}]$ and Poise

Assam CEE-2019

Ans. (a) :

$$\text{Modulus of elasticity} = \frac{\text{stress}}{\text{strain}}$$

$$\text{Stress} = \frac{F}{A} = [ML^{-1}T^{-2}]$$

Strain is dimensionless

$\therefore$ Modulus of elasticity= $[ML^{-1}T^{-2}]$

$$\text{Unit} = \frac{F}{A} = \text{Pascal}$$

202. The dimensional formula for pressure gradient of a liquid flowing in a tube is

(a) $[ML^{2}T^{-2}]$
(b) $[ML^{-1}T^{-2}]$
(c) $[MLT^{-2}]$
(d) $[ML^{-2}T^{-2}]$

AMU-2019

Ans. (d) : Since we know that pressure gradient is given as-

$$\text{Pressure gradient } = \frac{\Delta P}{\Delta h}$$

$$\text{unit of presser gradient } = \frac{N}{m^2} \times \frac{1}{m} = \frac{N}{m^3}$$

$$\text{Dimensional formula of pressure gradient } = \frac{\left[MLT^{-2}\right]}{\left[L^3\right]}$$

$$= \left[ML^{-2}T^{-2}\right]$$

Hence, option (d) is correct.

203. Consider a spongy block of mass m floating on a flowing river. The maximum mass of the block is related to the speed of the river flow v, acceleration due to gravity g and the density of the block ρ such that $m_{max} = kv^x g^y \rho^z$ (k is constant). The values of *x*, y and z should then respectively be (Mass of the spongy block is assumed to vary due to absorption of water by it)

(a) 6, 3, 2
(b) 6, –3, 1
(c) 3, 6, 1
(d) 6, 1, 3

TS-EAMCET-06.05.2019, Shift-1

Ans. (b) : The maximum mass of the block floating on river depends, speed of flow of the river (v) acceleration due to gravity (g) and density of the block (ρ)

So,

$$m_{max} = kv^x g^y \rho^z$$

Write the dimensional formula in both sides.

$$\left[M^1L^0T^0\right] = \left[LT^{-1}\right]^x \left[LT^{-2}\right]^y \left[ML^{-3}\right]^z$$

$$\left[M^1L^0T^0\right] = M^z L^{x+y-3z} T^{-x-2y}$$

Comparing the power we get,

$z = 1$ ...(i)

$x + y - 3z = 0$

$x + y - 3 \times 1 = 0$

$x + y = 3$ ...(ii)

$-x - 2y = 0$

$x = -2y$ ...(iii)

from equation (ii) and (iii) we get–

$y = -3$, $x = 6$

Then, the value of x, y and z will be

(6, –3, 1)

204. Match the physical quantities given in List-1 with dimensions in List-II.

List I	List II
(a) Gravitational potential	(i) $\left[M^0L^2T^{-2}K^{-1}\right]$
(b) Stefan's constant	(ii) $\left[M^{-1}L^3T^{-2}\right]$
(c) Permittivity	(iii) $\left[ML^0T^{-3}K^{-4}\right]$
(d) Specific heat capacity	(iv) $\left[M^{-1}L^{-3}T^4I^2\right]$

(The dimension of mass, length, time, temperature and current are M, L, T, K and I, respectively). The correct match is

	A	B	C	D
(a)	IV	I	III	II
(b)	I	IV	II	III
(c)	III	II	I	IV
(d)	II	III	IV	I

TS-EAMCET-03.05.2019, Shift-2

Ans. (d) : Dimensions of the given physical quantities are as follows :

(A) Gravitational potential,

$$= \left[m^3/kg.s^{-2}\right]$$

$$= \left[L^3/M^1T^{-2}\right]$$

$$= \left[M^{-1}L^3T^{-2}\right]$$

$$\text{(B) Stefan's constant } = \left(W/m^2K^4\right)$$

$$= [ML^2T^{-3}/L^2K^4]$$

$$= \left[ML^0T^{-3}K^{-4}\right]$$

$$\text{(C) Permittivity} = \frac{C^2}{N-m^2} \quad \left(C^2s^2/m^3kg\right)$$

$$= \left[M^{-1}L^{-3}T^4I^2\right]$$

$$\text{(D) Specific heat capacity } = (\text{Joule}/\text{kg.K})$$

$$= [ML^2T^{-2}/MK]$$

$$= \left[M^0L^2T^{-2}K^{-1}\right]$$

So, the correct sequence of match is

A → II, B → III, C → IV and D → I.

205. If A represents density, B represents velocity, C represents specific heat capacity and D represents wavelength, then the quantity having the dimensions of product of A, B, C and D is

(a) Stefan's constant
(b) Boltzmann's constant
(c) Thermal conductivity
(d) Universal gas constant

AP EAMCET (22.04.2019) Shift-II

@apna_pdf

Ans. (c) : Given that,

$$A = \text{Density} = \left[ML^{-3}T^{0}\right]$$

$$B = \text{Velocity} = \left[M^{0}LT^{-1}\right]$$

$$C = \text{Specific heat capacity} = \left[M^{o}L^{2}T^{-2}K^{-1}\right]$$

$$D = \text{Wavelength} = \left[M^{o}LT^{o}\right]$$

According to question dimension of ABCD is

$$[k] = [A][B][C][D]$$

$$[k] = \left[ML^{-3}\right]\left[LT^{-1}\right]\left[L^{2}T^{-2}K^{-1}\right][L]$$

$$[k] = \left[ML^{-3+1+2+1}T^{-1-2}K^{-1}\right]$$

$$[k] = \left[MLT^{-3}K^{-1}\right]$$

Dimensional formula of each option are -

Thermal conductivity = $\left[MLT^{-3}K^{-1}\right]$

Universal gas constant $= \left[ML^{2}T^{-2}K^{-1}\right]$

Stefan's constant $= \left[ML^{o}T^{-3}K^{-4}\right]$

Boltzmann's Constant $= \left[ML^{2}T^{-2}K^{-1}\right]$

Hence, dimension formula of ABCD is same as dimension formula of thermal conductivity.

206. A physical quantity obtained from the ratio of the coefficient of thermal conductivity to the universal gravitational constant has a dimensional formula [M^{2a} L^{4b} T^{2c} K^{d}], then the value of $\frac{a+b}{c+b}$ - d is

(a) $+\frac{3}{2}$ (b) $-\frac{1}{2}$

(c) $-\frac{3}{2}$ (d) $+\frac{1}{2}$

AP EAMCET (20.04.2019) Shift-II

Ans. (d) : Given that,

$$\frac{\text{Dimension formula of}[K]}{\text{Dimension formula of}[G]} = \left[M^{2a}L^{4b}T^{2c}K^{d}\right]$$

$$\frac{\left[M^{1}L^{1}T^{-3}K^{-1}\right]}{\left[M^{-1}L^{3}T^{-2}\right]} = \left[M^{2a}L^{4b}T^{2c}K^{d}\right]$$

$$M^{2a}L^{4b}T^{2c}K^{d} = \left[M^{2}L^{-2}T^{-1}K^{-1}\right]$$

Comparing both side, we get –

$$2a = 2,\ 4b = -2,\ 2c = -1,\ d = -1$$

$$a = 1 \quad b = \frac{-1}{2} \quad c = \frac{-1}{2}, d = -1$$

According to the question the value of

$$\frac{a+b}{c+b} - d = \frac{1-\frac{1}{2}}{-\frac{1}{2}-\frac{1}{2}} - (-1) = \frac{1}{2}$$

207. If the charge of electron e, mass of electron m, speed of light in vacuum c and Planck's constant h are taken as fundamental quantities, then the permeability of vacuum μ_0 can be expressed as

(a) $\frac{h}{mc^{2}}$ (b) $\frac{hc}{me^{2}}$

(c) $\frac{h}{ce^{2}}$ (d) $\frac{mc^{2}}{he^{2}}$

AP EAMCET (20.04.2019) Shift-1

Ans. (c) : Dimension of permeability of vacuum μ_o

$$\left[\mu_o\right] = \left[MLT^{-2}A^{-2}\right]$$

Dimension charge (e) = [AT]

Dimension of mass of electron (m) = [M]

Dimension of speed of light (c) = $[LT^{-1}]$

Dimension Planck's constant (h) = $[ML^{2}T^{-1}]$

According to question

$$\mu_o \propto e^{a}m^{b}c^{c}h^{d}$$

$$\mu_o = ke^{a}m^{b}c^{c}h^{d} \qquad .....(i)$$

$$\mu_o = k[AT]^{a}[M]^{b}\left[LT^{-1}\right]^{c}\left[ML^{2}T^{-1}\right]^{d}$$

$$\mu_o = k[M]^{b+d}[L]^{c+2d}[T]^{a-c-d}[A]^{a}$$

$$\left[MLT^{-2}A^{-2}\right] = K[M]^{b+d}[L]^{c+2d}[T]^{a-c-d}[A]^{a}$$

Comparing both side, we get –

$c + 2d = 1$ ......(ii)

$b + d = 1$ .....(iii)

$a - c - d = -2$ .....(iv)

$a = -2$ ......(v)

Solving the equation a = –2, b = 0, c = –1, d = 1,

Putting value of a, b, c, d in equation (i)

$$\mu_o = ke^{a}m^{b}c^{c}h^{d}$$

$$\mu_o = ke^{-2}m^{0}c^{-1}h^{1}$$

$$\mu_o = \frac{kh}{ce^{2}}$$

$$\mu_o = \frac{h}{ce^{2}}$$

Hence option (c) is correct answer.

208. If A represents Boltzmann constant, B represents Planck's constant and C represents speed of light in vacuum, then the quantity having the dimensions of $A^{4}B^{-3}C^{-2}$ is

(a) Universal gas constant

(b) Specific heat capacity

(c) Stefan's constant

(d) Heat energy

AP EAMCET (20.04.2019) Shift-1

@apna_pdf

Ans. (c) : Dimension of Boltzmann's constant (A)

$$=\left[ML^2T^{-2}K^{-1}\right]$$

Dimension of Planck constant $(B)=\left[ML^2T^{-1}\right]$

Dimension of speed of light $(C)=\left[LT^{-1}\right]$

The dimension of $A^4B^{-3}C^{-2}$ is –

$$=\left[ML^2T^{-2}K^{-1}\right]^4\left[ML^2T^{-1}\right]^{-3}\left[LT^{-1}\right]^{-2}$$

$$=\left[M^4L^8T^{-8}K^{-4}\right]\left[M^{-3}L^{-6}T^{+3}\right]\left[L^{-2}T^{+2}\right]$$

$$=\left[M^{4-3}L^{8-6-2}T^{-8+3+2}K^{-4}\right]=\left[M^1L^0T^{-3}K^{-4}\right]$$

We know $\left[M^1L^0T^{-3}K^{-4}\right]$ is dimension formula of Stefan's constant.

209. The dimensional formula of $\sqrt{\mu_r \in_r}$ is _____.

(a) $M^1L^{-1}T^{-2}A^{-1}$ (b) $M^1L^1T^{-2}A^0$

(c) $M^0L^0T^0A^0$ (d) $M^0L^2T^{-2}A^0$

GUJCET 2019

Ans. (c) : We know that,

$$v=\frac{c}{\sqrt{\mu_r\varepsilon_r}}$$

$$\sqrt{\mu_r\varepsilon_r}=\frac{c}{v}$$

$\frac{c}{v}$ is the ratio of velocity so it is dimensionless

So, the dimension of $\sqrt{\mu_r\varepsilon_r}$ is $M^0L^0T^0A^0$

210. The dimensional formula of jωL is _____. Take Q as the dimension of charge.

(a) $[M^{-1}L^2T^{-1}Q^{-2}]$ (b) $[M^1L^{-2}T^{-1}Q^{-2}]$

(c) $[M^1L^2T^{-1}Q^{-2}]$ (d) $[M^1L^2T^1Q^{-2}]$

GUJCET 2019

Ans. (c) : [jωL]

Where, j = Complex number

ω = angular frequency

L = inductance

$j\omega L=[M^0L^0T^0]\,[M^0L^0T^{-1}]\,[M^1L^2T^0Q^{-2}]$

Dimension of $j\omega L=[M^1L^2T^{-1}Q^{-2}]$

211. The dimensional formula of effective torsional constant of spring is _____.

(a) $[M^1L^2T^{-3}]$ (b) $[M^1L^2T^{-2}A^{-2}]$

(c) $[M^1L^2T^{-2}]$ (d) $[M^0L^0T^0]$

GUJCET 2019

Ans. (c) : $\tau = C\theta$

where,

C = torsional constant of spring

τ = restoring torque

θ = angle

Dimension of $\theta=[M^0L^0T^0]$

$$\tau=M^1L^2T^{-2}$$

$$C=\left[\frac{\tau}{\theta}\right]=\frac{[M^1L^2T^{-2}]}{[M^0L^0T^0]}$$

$$C=[M^1L^2T^{-2}]$$

212. What is the dimension of Luminous flux?

(a) $[cd^1]$ (b) $[cd^1T^{-1}]$

(c) $[cd^1L^{-2}]$ (d) $[cd^1L^1T^{-1}]$

AIIMS-26.05.2019(M) Shift-1

Ans. (a) : The unit of luminous intensity is Candela and denoted as cd.

So, the unit of luminous flux = [cd]

213. Which of the following is the dimensional formula for electric polarization

(a) $M^0L^{-1}T^1I^1$ (b) $M^0L^{-2}T^1I^1$

(c) $M^{-1}L^{-2}T^1I^1$ (d) $M^{-1}L^{-2}T^1I^{-1}$

MHT-CET 2019

Ans. (b) : Dimensional formula for electric polarization is $[M^0L^{-2}T^1I^1]$.

Electric polarization $(P)=\varepsilon_0\,\chi\,E$

Where, E = electric field

χ = electric susceptibility (dimensionless)

$$[P]=[\varepsilon_0][E]\quad :\chi\text{ is dimensionless}$$

$$[P]=\left[M^{-1}L^{-3}T^4I^2\right]\left[MLT^{-3}I^{-1}\right]$$

$$[P]=\left[M^0L^{-2}T^1I^1\right]$$

214. The dimensional formula of coefficient of viscosity can be expressed as $M^a\,L^b\,T^c$. What are the values of a, b and c.

(a) a = b = c = 1 (b) a = b = 1 , c = –1

(c) a = 1, b = c = –1 (d) a = c = –1, b = 1

J&K-CET-2019

Ans. (c) : Coefficient of viscosity $(\eta)=\frac{F\times r}{A\times v}$

Where, F = Tangential force

r = Distance between layers

A = Area

v = Velocity

$$\text{Dim. }(\eta)=\frac{F\times r}{A\times v}$$

$$=\frac{\left[MLT^{-2}\right]\times[L]}{\left[L^2\right]\times\left[L^1T^{-1}\right]}$$

$$=\frac{\left[ML^2T^{-2}\right]}{\left[L^3T^{-1}\right]}=\left[ML^{-1}T^{-1}\right]$$

Hence, an comparing with $[M^aL^bT^c]$

We get, a = 1, b = –1, c = –1.

215. Which of the following is a dimensionless quantity?

(a) Thermal conductivity

(b) Specific gravity

(c) Coefficient of linear expansion

(d) Surface tension

J&K-CET-2019

@apna_pdf

Ans. (b) : Density $= \dfrac{\text{Mass}}{\text{Volume}} = \left[ML^{-3}\right]$

Specific gravity $= \dfrac{\text{Density of substance}}{\text{Density of water at } 4^{\circ}\text{C}}$

Dim. of specific gravity $= \dfrac{\left[ML^{-3}\right]}{\left[ML^{-3}\right]}$

$= \left[M^0L^0\right]$

Hence, specific gravity is a dimensionless quantity.

216. The dimensions of torque are same as that of

(a) Pressure (b) impulse
(c) moment of force (d) acceleration

MHT-CET 2019

Ans. (c) : Torque = Force × Distance

$= \left[ML^1T^{-2}\right] \times \left[M^0L^1T^0\right]$

$= \left[ML^2T^{-2}\right]$

Moment of force = force × Distance

$= \left[ML^1T^{-2}\right] \times \left[M^0L^1T^0\right]$

$= \left[ML^2T^{-2}\right]$

217. If force is proportional to square of velocity, then the dimension of proportionality constant is

(a) $[ML^{-1}T]$ (b) $[ML^{-1}T^0]$
(c) $[MLT^0]$ (d) $[M^0LT^{-1}]$

Manipal UGET-2019, 2010

Ans. (b) : According to question–

$F \propto V^2$

$F = kV^2$ (k = proportionality const.)

Write dimension on both side

$[MLT^{-2}] = k[LT^{-1}]^2$

$= k[L^2T^{-2}]$

$k = \dfrac{\left[MLT^{-2}\right]}{\left[L^2T^{-2}\right]}$

$k = \left[ML^{-1}T^0\right]$

218. Which of the following physical quantities set has different dimensional formulae :

(a) Angular Impulse. Planks constant. Stefan's constant
(b) Energy density. Wave Intensity. Stress
(c) Radius of gyration. Angular displacement. Rydberg constant
(d) Velocity gradient. Acceleration. Gravitational Potential

TS EAMCET 02.05.2018, Shift-II

Ans. (d) : Angular impulse = Torque × time

= (force × distance) × (time)

$= [MLT^{-2}]\,[L]\,[T]$

$= [ML^2T^{-1}]$

Dimension of plank's constant $[h] = [ML^2T^{-1}]$

Stefan's constant $(\sigma) = [ML^0T^{-3}K^{-4}]$

Energy density $= [ML^{-1}T^{-2}]$

Wave intensity $= [ML^0T^{-3}]$

Stress $= [M^1L^{-1}T^{-2}]$

Radius of gyration $= [M^0L^0T^0]$

Angular displacement $= [M^0L^0T^0]$

Rydberg constant $= [M^0L^{-1}T^0]$

Velocity gradient $= [M^0L^0T^{-1}]$

Acceleration $= [LT^{-2}]$

Gravitational potential $= [M^0L^2T^{-2}]$

219. If L represents inductance, R represents resistance and Q represents electric charge, then match the following.

List-I (Quantity)	**List-II (Dimensions)**
(A) $\dfrac{Q^2R^2}{L}$	I) $M^2\,L^4\,T^{-5}\,A^{-2}$
(B) $\dfrac{Q^2R^3}{L}$	II) $M^0\,L^0\,T^0\,A^1$
(C) $\dfrac{QR^2}{L}$	III) $M^1\,L^2\,T^{-2}\,A^0$
(D) $\dfrac{QR}{L}$	IV) $M^1\,L^2\,T^{-3}\,A^{-1}$

The correct is

	A	**B**	**C**	**D**
(a)	IV	III	II	I
	A	B	C	D
(b)	III	I	IV	II
	A	B	C	D
(c)	IV	III	I	II
	A	B	C	D
(d)	III	IV	I	II

AP EAMCET-25.04.2018, Shift-II

Ans. (b) : $Q = It$

$[Q] = [AT]$

$R = \dfrac{W}{QI}$

$[R] = \dfrac{\left[ML^2T^{-2}\right]}{[AT][A]} = \left[ML^2T^{-3}A^{-2}\right]$

$L = V \times \dfrac{dt}{di}$

$= \dfrac{W}{Q} \cdot \dfrac{dt}{di}$

$[L] = \dfrac{\left[ML^2T^{-2}\right]}{[AT]} \cdot \dfrac{[T]}{[A]}$

$= \left[ML^2T^{-2}A^{-2}\right]$

$\dfrac{Q^2R^2}{L}$

(A) $\left[\dfrac{Q^2R^2}{L}\right] = \dfrac{\left[A^2T^2\right]\left[ML^2T^{-3}A^{-2}\right]^2}{\left[ML^2T^{-2}A^{-2}\right]}$

$= \left[ML^2T^{-2}A^0\right]$

@apna_pdf

(B) $$\left[\frac{Q^2R^3}{L}\right]=\frac{\left[A^2T^2\right]\left[ML^2T^{-3}A^{-2}\right]^3}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[M^2L^4T^{-5}A^{-2}\right]$$

(C) $$\left[\frac{QR^2}{L}\right]=\frac{\left[AT\right]\left[ML^2T^{-3}A^{-2}\right]^2}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[ML^2T^{-3}A^{-1}\right]$$

(D) $$\left[\frac{QR}{L}\right]=\frac{\left[AT\right]\left[ML^2T^{-3}A^{-2}\right]}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[M^0L^0T^0A^1\right]$$

220. If L represents inductance, R represents resistance and Q represents electric charge, then match the following.

List-I (Quantity)	**List-II (Dimensions)**
(A) $\frac{Q^2R^2}{L}$	I) $M^2\,L^4\,T^{-5}\,A^{-2}$
(B) $\frac{Q^2R^3}{L}$	II) $M^0\,L^0\,T^0\,A^1$
(C) $\frac{QR^2}{L}$	III) $M^1\,L^2\,T^{-2}\,A^0$
(D) $\frac{QR}{L}$	IV) $M^1\,L^2\,T^{-3}\,A^{-1}$

The correct is

	A	**B**	**C**	**D**
(a)	IV	III	II	I
	A	B	C	D
(b)	III	I	IV	II
	A	B	C	D
(c)	IV	III	I	II
	A	B	C	D
(d)	III	IV	I	II

AP EAMCET-25.04.2018, Shift-II

Ans. (b) : $Q = It$

$$[Q]=[AT]$$

$$R=\frac{W}{QI}$$

$$[R]=\frac{\left[ML^2T^{-2}\right]}{[AT][A]}=\left[ML^2T^{-3}A^{-2}\right]$$

$$L=V\times\frac{dt}{di}$$

$$=\frac{W}{Q}\cdot\frac{dt}{di}$$

$$[L]=\frac{\left[ML^2T^{-2}\right]}{[AT]}\cdot\frac{[T]}{[A]}$$

$$=\left[ML^2T^{-2}A^{-2}\right]$$

$$\frac{Q^2R^2}{L}$$

(A) $$\left[\frac{Q^2R^2}{L}\right]=\frac{\left[A^2T^2\right]\left[ML^2T^{-3}A^{-2}\right]^2}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[ML^2T^{-2}A^0\right]$$

(B) $$\left[\frac{Q^2R^3}{L}\right]=\frac{\left[A^2T^2\right]\left[ML^2T^{-3}A^{-2}\right]^3}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[M^2L^4T^{-5}A^{-2}\right]$$

(C) $$\left[\frac{QR^2}{L}\right]=\frac{\left[AT\right]\left[ML^2T^{-3}A^{-2}\right]^2}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[ML^2T^{-3}A^{-1}\right]$$

(D) $$\left[\frac{QR}{L}\right]=\frac{\left[AT\right]\left[ML^2T^{-3}A^{-2}\right]}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[M^0L^0T^0A^1\right]$$

221. The dimensions in M, L and T of the term a/V^2 in Vander Waals equation are

(a) 1, –1, –2
(b) 1, 1, –2
(c) 2, 1, –1
(d) 1, 1, 1

Assam CEE-2018

Ans. (a) The Vanderwaal's equation is given as –

$$\left(P+\frac{a}{V^2}\right)(V-b)=RT$$

Therefore, a/V^2 should have same dimension as P (pressure).

So, dimension of $\left(\frac{a}{V^2}\right)=M^1L^{-1}T^{-2}$

222. The radius of nucleus is $R = R_0A^{1/3}$, where A is mass number. The dimension of R_0 is

(a) $[MLT^{-2}]$
(b) $[M^0LT^0]$
(c) $[M^0LT^{-1}]$
(d) None of these

HP CET-2018

Ans. (b) : Given, that:-

The radius of nucleus $R = R_0A^{1/3}$

$$\text{or } R_0=\frac{R}{(A)^{1/3}}$$

A is mass number so, it is dimensionless

So, dimension of R_0 = dimension of R

$= [L] = [M^0LT^0]$

223. If energy of photon is $E \alpha\, h^a\, c^b\, \lambda^d$ where, h is Planck's constant, c = speed of light and λ = wavelength of photon. Then the value of a, b and d are

(a) 1, 1, 1
(b) 1, –1, 1
(c) 1, 1, –1
(d) None of these

HP CET-2018

@apna_pdf

Ans. (c) : We have :-

$$E \propto h^a c^b \lambda^d$$

We know that :-

$$[E] = [M^1L^2T^{-2}]$$
$$[h] = [M^1L^2T^{-1}]$$
$$[c] = [L^1T^{-1}]$$
$$[\lambda] = [L^1]$$

So, $[E] = [h]^a[c]^b[\lambda]^d$

$$[M^1L^2T^{-2}] = [M^1L^2T^{-1}]^a[L^1T^{-1}]^b[L^1]^d$$
$$[M^1L^2T^{-2}] = [M^aL^{2a+b+d}T^{-a-b}]$$

On comparing coff. of M, L and T both sides:-

$$a = 1$$
$$2a + b + d = 2$$
$$-a - b = -2$$
$$-1 - b = -2 \quad (\because a = 1)$$
$$-b = -2 + 1$$
$$b = 1$$

Put a = 1, b = 1 in 2a + b + d = 2

$$2 + 1 + d = 2 \Rightarrow d = -1$$

So, the value of a, b, d are :-

a, b, d = 1, 1, –1

224. If V_0 is the volume of a standard unit cell of germanium crystal containing N_0 atoms, then the expression for the mass m of a volume V in terms of V_0, N_0, M_{mol} and N_A is [here, M is the molar mass of germanium and N_A is the Avogadro's constant]

(a) $M\dfrac{V}{V_0}\dfrac{N_A}{N_0}$
(b) $\dfrac{N_A}{N_0}\dfrac{V_0}{V}M$
(c) $M\dfrac{V}{V_0}\dfrac{N_0}{N_A}$
(d) $M\dfrac{V_0}{V}\dfrac{N_0}{N_A}$

TS-EAMCET-05.05.2018, Shift-1

Ans. (c) : Number of unit cells in volume

$$= \frac{\text{Total volume}}{\text{Volume of a unit cell}} = \frac{V}{V_0}$$

Number of atoms in volume (V)

=Number of unit cells × Number of atoms in (N_0)

$$1 \text{ unit cell} = \frac{V}{V_0} \times N_0$$

Number of moles in volume (V)

$$= \frac{\text{Number of atoms}}{\text{Avagadro number}} = \frac{V}{V_0} \times \frac{N_0}{N_A}$$

Mass m of given sample volume

= Number of moles × Molar mass

$$\therefore \quad m = \frac{V}{V_0} \times \frac{N_0}{N_A} \times M$$

225. A gas satisfies the relation $PV^{5/3} = k$, where P is pressure, V is volume and k is constant. The dimension of constant k are

(a) $[ML^4T^{-2}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^6T^{-2}]$
(d) $[MLT^{-2}]$

TS-EAMCET-04.05.2018, Shift-1

Ans. (a) : Given, $PV^{5/3} = k$, $\left\{\begin{matrix} P = \text{pressure} \\ V = \text{volume} \end{matrix}\right\}$

Using dimensional balance method

$$k = [P]\,[V]^{5/3} = [ML^{-1}T^{-2}] \times [L^3]^{5/3}$$
$$= [ML^{-1}T^{-2}] \times [L^5]$$
$$= [ML^4T^{-2}]$$

226. Dimensions of the quantity $\dfrac{P}{\varepsilon_0\mu_0}$, where p is the pressure, ε_0 is electric permittivity of free space and μ_0 is permeability of free space, will be

(a) $[MLT^{-4}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^3T^{-3}]$
(d) $[ML^2T^{-4}]$

TS-EAMCET-07.05.2018, Shift-1

Ans. (a) : Given,

$$\text{Quantity} = \frac{P}{\varepsilon_0\mu_0}$$

Where, P = Pressure, ε_0 = permittivity of free space and μ_0 = Permeability of free space.

So,

$$\text{Dimension of } \frac{P}{\varepsilon_0\mu_0} = \left[ML^{-1}T^{-2}\right] \times \left[L^2T^{-2}\right]$$
$$= [MLT^{-4}]$$

227. If C, the velocity of light, g the acceleration due to gravity and P the atmospheric pressure be the fundamental quantities in MKS system, then the dimensions of length will be same as that of

(a) $\dfrac{C}{g}$
(b) $\dfrac{C}{P}$
(c) PCg
(d) $\dfrac{C^2}{g}$

BITSAT-2018

Ans. (d) : C = velocity

g = acceleration due to gravity

P = Atmospheric Pressure

$$\text{Dimension of } \left(\frac{C^2}{g}\right) = \frac{\left[LT^{-1}\right]^2}{\left[LT^{-2}\right]} = \frac{\left[L^2T^{-2}\right]}{\left[LT^{-2}\right]} = [L]$$

$$\text{Dimension of } \frac{C}{P} = \frac{\left[LT^{-1}\right]}{[ML^{-1}T^{-2}]} = \left[M^{-1}L^2T\right]$$

Dimension of

$$PCg = \left[ML^{-1}T^{-2}\right]\left[LT^{-1}\right]\left[LT^{-2}\right] = \left[MLT^{-5}\right]$$

$$\text{Dimension of } \frac{C}{g} = \frac{\left[LT^{-1}\right]}{\left[LT^{-2}\right]} = [T]$$

Hence, only option (d) is correct dimension of length.

228. Assertion (A) : Energy per unit volume and angular momentum can be added dimensionally.

Reason (R): Physical quantities having same dimensions can be added or subtracted.

@apna_pdf

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(c) (A) is true but (R) is false
(d) (A) is false but (R) is true

AP EAMCET (23.04.2018) Shift-1

Ans. (d) : Due to dimensionally not equal, angular momentum can not be added dimensionally to energy per unit volume. Hence, Assertion (A) is false. Physical quantities have same dimensions can be added or subtracted. Hence Reason (R) is correct.

229. The magnetic induction field has the dimensions of
(a) force
(b) force constant
(c) surface tension
(d) $\frac{\text{surface tension}}{\text{current}}$
(e) force constant λ current

Kerala CEE -2018

Ans. (d) : Magnetic Induction force (F) = qvB

Or $$B = \frac{F}{qv} = \frac{F}{q\left(\frac{L}{t}\right)}$$

Or $$B = \frac{F}{Li} \quad \left(\because \; v = \frac{L}{t}, i = \frac{q}{t}\right)$$

Or $$B = \frac{F}{L} \times \frac{1}{i}$$

We know that, surface tension = $\frac{\text{force}}{\text{length}}$

Dimension of $B = \frac{\text{surface tension}}{\text{current}}$

230. The dimensional formula of mobility is ______.
(a) $[M^{-1}L^1T^2A^1]$ (b) $[M^1L^0T^2A^{-1}]$
(c) $[M^1L^{-1}T^{-2}A^{-1}]$ (d) $[M^{-1}L^0T^2A^1]$

GUJCET 2018

Ans. (d) : Mobility $(\mu) = \frac{\text{Drift velocity}(V_d)}{\text{Electric field}(E)}$

Drift velocity is a type of velocity and it can have the same dimensional formula as that of velocity.
$[V_d] = [M^0L^1T^{-1}]$
Electric field is a force per unit charged.

$$E = \frac{[F]}{[q]} = \frac{[MLT^{-2}]}{[AT]} = [M^1L^1T^{-3}A^{-1}]$$

$$\mu = \frac{[V_d]}{[E]} = \frac{[M^0L^1T^{-1}]}{[M^1L^1T^{-3}A^{-1}]}$$
$$= [M^{-1}L^0T^2A^1]$$

231. The dimensional formula of $\mu_0\varepsilon_0$ is ______.
(a) $[M^0L^{-2}T^2]$ (b) $[M^0L^2T^{-2}]$
(c) $[M^0L^1T^{-1}]$ (d) $[M^0L^{-1}T^1]$

GUJCET 2018

Ans. (a) : Speed of light $(C) = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

Squaring both side,

$$C^2 = \frac{1}{\mu_0\varepsilon_0}$$

$$\mu_0\varepsilon_0 = \frac{1}{C^2}$$

Dimensional formula of speed (C) = $[LT^{-1}]$

So, $$\mu_0\varepsilon_0 = \frac{1}{[L^1T^{-1}]^2}$$
$$= \frac{1}{[L^2T^{-2}]}$$
$$\mu_0\varepsilon_0 = [M^0L^{-2}T^2]$$

232. Gravitational constant (G), Planck's constant (h) and Velocity of light (c) are
(a) Dimensional variables
(b) Dimensionless variables
(c) Non-dimensional constants
(d) Dimensional constants

J&K-CET-2018

Ans. (d) : The physical quantities which have dimensions and a fixed value are known as dimensional constant.
Gravitational constant G has a fixed value of 6.67×10^{-11} Nm^2 /Kg^2.
Planck's constant (h) has a fixed value of 6.626×10^{-34}Js
Velocity of light (c) has a fixed value of 3×10^8 m/s

233. The velocity of water waves (v) may depend on their wavelength λ, the density of water ρ and the acceleration due to gravity g. The method of dimensions gives the relation between these quantities is
(a) v (b) $v^2 \propto g\lambda$
(c) $v^2 \propto g\lambda^2$ (d) $v^2 \propto g^{-1}\lambda^2$

AIIMS-26.05.2018(E)

Ans. (b) : Let, $v \propto \lambda^a\rho^bg^c$

The dimensional formula for all quantities we get,

$$[LT^{-1}] \propto [L]^a[ML^{-3}]^b[LT^{-2}]^c$$
$$[M^0L^1T^{-1}] \propto [M^bL^{a-3b+c}T^{-2c}]$$

Comparing power of M,L and T

b = 0, $a - 3b + c = 1$, and $-2c = -1$

$$a - 3 \times 0 + \frac{1}{2} = 1 \qquad c = \frac{1}{2}$$

$$a = 1 - \frac{1}{2} = \frac{1}{2}$$

$$a = \frac{1}{2}$$

$\therefore$ $$v \propto \lambda^{1/2}\rho^0g^{1/2}$$
$$v = \sqrt{\lambda g}$$

So, $$v^2 \propto \lambda g$$

@apna_pdf

234. A physical quantity 'P' is given by $P = \in_0 L\frac{\Delta V}{\Delta t}$, where $\in_0$ is electric permittivity, L is length, ΔV is potential difference and Δt is time interval. The dimensional formula of P is same as that of

(a) resistance (b) electric charge
(c) voltage (d) electric current

AP EAMCET-24.04.2017, Shift-II

Ans. (d) :

$$P = \varepsilon_0 L\frac{\Delta v}{\Delta t} \qquad \ldots(i)$$

where ε_0 = electric permittivity

$= [M^{-1}L^{-3}T^4A^2]$

L = length = [L]

$\Delta t = [T]$

Keep these values in eq. (i)

$$[P] = [\varepsilon_0][L]\frac{[\Delta v]}{[\Delta t]}$$

$$[P] = \left[M^{-1}L^{-3}T^4A^2\right][L]\frac{\left[ML^2T^{-3}A^{-1}\right]}{[T]}$$

$$= \left[M^0L^0T^0A^1\right]$$

Electric current unit is Ampere

It mean P has same dimensions as of current

235. A rectangular beam which is supported at its two ends and loaded in the middle with weight W sags by an amount δ Such that $\delta = \left[\frac{wl^3}{4Yd^3?}\right]$, where *l*, *d* and Y represent length, depth and elasticity respectively. Guess the unknown factor using dimensional considerations.

(a) breadth (b) $(\text{breadth})^2$
(c) $(\text{breadth})^3$ (d) mass

COMEDK 2017

Ans. (a): Let unknown factor be x

$$\delta = \left[\frac{wl^3}{4Yd^3x}\right]$$

$$x = \left[\frac{wl^3}{4Yd^3\delta}\right]$$

where, w = weight

l = length

d = depth

Y = elastic property

δ = Saging So,

$$x = \frac{\left[MLT^{-2}\right]\left[L^3\right]}{\left[\frac{MLT^{-2}}{L^2}\right]\left[L^3\right][L]}$$

$$x = \frac{\left[L^2\right]}{[L]} = [L]$$

Thus unknown factor x represent breadth.

236. P, Q and R are physical quantities having different dimensions, then the following combination never be a meaningful quantity

(a) $\frac{PQ}{R}$ (b) $\frac{R}{PQ}$
(c) $\frac{Q^2}{PR}$ (d) $\frac{PQ}{R+Q}$

AP EAMCET-28.04.2017, Shift-I

Ans. (d) :

$\frac{PQ}{R+Q} \rightarrow$. This combination can never be a combination because physical quantity having different dimension cannot be added or subtracted.

237. What is the dimension of $\frac{1}{\mu_0\varepsilon_0}$?

(μ_o= magnetic permeability and

(ε_o= permittivity of free space)

(a) $[L^2T^{-2}]$ (b) $[LT^{-1}]$
(c) $[L^2T^2]$ (d) $[LT^2]$

TS-EAMCET-11.09.2020, Shift-1

CGPET-2018

Ans. (a) : ∵ The speed of the light in vacuum is

$$C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$C^2 = \frac{1}{\mu_0\varepsilon_0}$$

$$\frac{1}{\mu_0\varepsilon_0} = \left[LT^{-1}\right]^2 = \left[L^2T^{-2}\right]$$

238. Out of the following pairs, which one does not have identical dimensions?

(a) Angular momentum and Planck's constant
(b) Impulse and momentum
(c) Moment of inertia and moment of a force
(d) Work and torque

AIEEE 2005

Ans. (c) : Moment of inertia and moment of force

Moment of Inertia (I) = Mr^2

I = $[M^1L^2T^0]$ and

Moment of a force (τ) = F.d

= $[M^1L^1T^{-2}][L]$

= $[M^1L^2T^{-2}]$

So, Moment of inertia and moment of a force does not have identical dimension.

239. The dimensions of magnetic field in M, L, T and C (coulomb) is given as

(a) $\left[MLT^{-1}C^{-1}\right]$ (b) $\left[MT^2C^{-2}\right]$
(c) $\left[MT^{-1}C^{-1}\right]$ (d) $\left[MT^2C^{-1}\right]$

AIEEE 2008

@apna_pdf

Ans. (c) : We know that,

Lorentz Force (F) = q v × B

$$[B]=\frac{[F]}{[q][v]}$$

$$=\frac{\left[MLT^{-2}\right]}{[C][LT^{-1}]}$$

$$[B] = [MT^{-1}C^{-1}]$$

240. Let [ε₀] denotes the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then

(a) $[\varepsilon_o]=\left[M^{-1}L^{-3}T^{2}A\right]$

(b) $[\varepsilon_o]=\left[M^{-1}L^{-3}T^{4}A^{2}\right]$

(c) $[\varepsilon_o]=\left[M^{-2}L^{2}T^{-1}A^{-2}\right]$

(d) $[\varepsilon_o]=\left[M^{-1}L^{2}T^{-1}A^{2}\right]$

JEE Main 2013

Ans. (b) : We know that,

$$F=\frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}$$

$$[\varepsilon_o]=\frac{[q_1][q_2]}{[F][r^2]}=\frac{[it][it]}{[F][r^2]}$$

$$[\varepsilon_o]=\frac{[IT][IT]}{[MLT^{-2}][L^2]}$$

$$[\varepsilon_0] = [M^{-1}L^{-3}T^4I^2]$$

241. The dimensional formula of coefficient of kinematic viscosity is:

(a) $[M^0L^{-1}T^{-1}]$ (b) $[M^0L^2T^{-1}]$

(c) $[ML^2T^{-1}]$ (d) $[ML^{-1}T^{-1}]$

AP EAMCET(Medical)-2002

Ans. (b) : The dimensional formula of kinematic viscosty is $[M^0L^2T^{-1}]$.

242. The dimensional formula of magnetic induction is:

(a) $[MT^{-1}A^{-1}]$ (b) $[MT^{-2}A^{-1}]$

(c) $[MTA^{-2}]$ (d) $[MTA^{-2}]$

AP EAMCET(Medical)-2000

Ans. (b) : The dimensional formula of magnetic induction is $[MT^{-2}A^{-1}]$.

243. Which of the following physical quantities represent the dimensions of $\frac{b}{a}$ in the relation $P=\frac{x^2-b}{at}$, where P is power, x is distance and t is time

(a) Power (b) Surface tension

(c) Torsional constant (d) Force

AP EAMCET(Medical)-2016

Ans. (c) : Given,

$$P=\frac{x^2-b}{at}$$

The dimension of b = The dimension of x^2

$\therefore \quad [b] = [L^2]$------------(1)

Also,

$[P] = [M^1L^2T^{-3}]$

$[t] = [T^1]$

$$[a]=\frac{[b]}{[P][t]}=\frac{[L^2]}{[ML^2T^{-3}][T]}$$

$[a] = [M^{-1}T^2]$---------------(2)

$$\therefore \quad \frac{[b]}{[a]}=\frac{[L^2]}{[M^{-1}T^2]}=[ML^2T^{-2}]\text{---------(3)}$$

Torsional constant $k=\frac{\tau}{\theta}$

$\therefore \quad [k] = [\tau]$

$[k] = [ML^2T^{-2}]$-------------(4)

From 3 and 4,

$$\frac{[b]}{[a]}=k$$

244. If energy (E), force (F) and linear momentum (P) are fundamental quantities, then match the following and give the correct answer.

(A) **Physical quantity**	**(B)** **Dimensional formula**
(a) Mass	(d) $[E^0\,F^{-1}\,P^1]$
(b) Length	(e) $[E^{-1}\,F^0\,P^2]$
(c) Time	(f) $[E^1\,F^{-1}\,P^0]$

(a) a-d, b-e, c-f (b) a-f, b-e, c-d

(c) a-e, b-f, c-d (d) a-e, b-d, c-f

AP EAMCET(Medical)-2015

Ans. (c) :

(A) **Physics quantity**	**(B)** **Dimensional formula**
(A) Mass	(E) $E^{-1}\,F^0\,p^2$
(B) Length	(F) $E^1\,F^{-1}\,p^0$
(C) Time	(D) $E^0\,F^{-1}\,p^1$

245. In the equation $\left(\frac{1}{p\beta}\right)=\frac{y}{K_BT}$, where p is the pressure, y is the distance, K_B is Boltzmann constant and T is the temperature Dimensions of β are

(a) $[M^{-1}L^1T^2]$ (b) $[M^0L^2T^0]$

(c) $[M^1L^{-1}T^{-2}]$ (d) $[M^0L^0T^0]$

AP EAMCET(Medical)-2013

Ans. (b) : From the equation $=\frac{1}{p.\beta}=\frac{y}{K_BT}$

$$\beta=\frac{K_BT}{p.y}=\frac{[ML^2T^{-3}][T]}{[ML^{-1}T^{-2}][L]}$$

$$=\frac{[ML^2T^{-2}]}{[ML^0T^{-2}]}=[M^0L^2T^0]$$

Hence, the dimension of β is $[L^2]$

@apna_pdf

246. The van der Waal's equation for n moles of a real gas is

$$\left(p+\frac{a}{V^2}\right)(V-b)=nRT$$

Where p is pressure, V is volume, T is absolute temperature, R is molar gas constant a, b and c are van der Waal's constants. The dimensional formula for ab is

(a) $[ML^8L^{-2}]$ (b) $[ML^6L^{-2}]$
(c) $[ML^4L^{-2}]$ (d) $[ML^2L^{-2}]$

AP EAMCET(Medical)-2012

Ans. (a) : P must be same as $\frac{a}{V^2}$

Hence, $\frac{[a]}{L^6}=\left[ML^{-1}T^{-2}\right]$

$[a]=\left[ML^5T^{-2}\right]$

The dimension of b must be same as that of V

Hence, $[b]=L^3$

$[ab]=\left[ML^8T^{-2}\right]$

247. If force (F), work (W) and velocity (v) are taken as fundamental quantities, then the dimensional formula of time (T) is:

(a) [WFv] (b) $[WFv^{-1}]$
(c) $[W^{-1}F^{-1}v]$ (d) $[WF^{-1}v^{-1}]$

AP EAMCET(Medical)-2007

Ans. (d) : Force = F

Work = W

Velocity = v

Let the distance be 'd' and the time be t Distance can be expressed as d = v ×t

Work done by an object is given by.

$W = F \times d$

$= F \times v \times t$

$t=\frac{W}{Fv}$

$t=\left[W^1F^{-1}v^{-1}\right]$

Hence, the dimensional formula of the time will be $[WF^{-1}v^{-1}]$

248. Some physical constants are given in List 1 and their dimensional formulae are given in List 2. Match the correct pairs in the lists:

List 1	List 2
(A) Planck's constant	(1) $[ML^{-1}T^{-2}]$
(B) gravitational constant	(2) $[ML^{-1}T^{-2}]$
(C) bulk modulus	(3) $[ML^2T^{-1}]$
(D) coefficient of viscosity	(4) $[M^{-1}L^3T^{-2}]$

(a) (1) D, (2) C, (3) B, (4) A
(b) (1) B, (2) A, (3) C, (4) D
(c) (1) C, (2) B, (3) A, (4) D
(d) (1) C, (2) D, (3) A, (4) B

EAMCET-2007
AP EAMCET(Medical)-2006

Ans. (d) :

$h=\frac{E}{\nu}=\frac{\left[ML^2T^{-2}\right]}{\left[T^{-1}\right]}$

$h=\left[ML^2T^{-1}\right]$

- Gravitational constant (G)

$g=\frac{GM}{R^2}$

$G=\frac{gR^2}{M}$

$G=\frac{\left[LT^{-2}\right]\left[L^2\right]}{[M]}$

$G=\left[M^{-1}L^3T^{-2}\right]$

- Bulk modulus (K)= $K=-V\frac{dP}{dV}$

Where, P = Pressure
V = Volume
P = F/A

$$K=\frac{F/A}{\left\{\frac{\Delta V}{V}\right\}}$$

$$K=\frac{F}{A}=\frac{\left[MLT^{-2}\right]}{\left[L^2\right]}$$

$$K=\left[M^1L^{-1}T^{-2}\right]$$

- Coefficient of viscosity $(\eta)=\frac{F}{A.\left\{\frac{dv}{dx}\right\}}$

$$(\eta)=\frac{\left[MLT^{-2}\right]}{\left[L^2\right]\left[T^{-1}\right]}$$

$$=\left[ML^{-1}T^{-1}\right]$$

249. According to Bernoulli's theorem $\frac{P}{d}+\frac{V^2}{2}+gh=\text{constant}$. The dimensional formula of the constant is: (P = pressure, d = density, h = height, V = velocity and g = acceleration due to gravity)

(a) $[M^0L^0T^0]$ (b) $[M^0LT^0]$
(c) $[M^0L^2T^{-2}]$ (d) $[M^0L^2T^{-4}]$

AP EAMCET(Medical)-2005

Ans. (c) : Bernoulli's theorem $\frac{P}{d}+\frac{V^2}{2}+gh=\text{constant}$

Dimensional formula of the constant is same as dimensional formula of $\frac{P}{d}$, $\frac{V^2}{2}$, gh.

So, dimensional formula of gh = $[LT^{-2}][L]$
$= [L^2T^{-2}]$
$= [M^0L^2T^{-2}]$

@apna_pdf

250. The dimensional formula of the product of two physical quantities P and Q is $[ML^2T^{-2}]$. The dimensional formula of $\frac{P}{Q}$ is $[MT^{-2}]$ P and Q respectively are:

(a) force, velocity
(b) momentum, displacement
(c) force, displacement
(d) work, velocity

AP EAMCET(Medical)-2001

Ans. (c) : Given, $PQ = [ML^2T^{-2}]$

$$\frac{P}{Q} = [MT^{-2}]$$

$$PQ \times \frac{P}{Q} = ML^2T^{-2} \times MT^{-2}$$

$$P^2 = M^2L^2T^{-4}$$

$$P = MLT^{-2} = \text{Force}$$

Now,

$$\frac{PQ}{\left(\frac{P}{Q}\right)} = \frac{PQ}{P} \times Q = \frac{ML^2T^{-2}}{MT^{-2}}$$

$$Q^2 = L^2$$

$$Q = L \quad = \text{Displacement}$$

251. If m is mass Q is charge and B is magnetic induction, then $\frac{m}{BQ}$ has the same dimensions as:

(a) frequency
(b) $\frac{1}{\text{frequency}}$
(c) velocity
(d) acceleration

AP EAMCET(Medical)-1999

Ans. (b) : Magnetic induction $(B) = ML^0T^{-2}A^{-1}$

Charge $(Q) = TA$

Mass $(m) = M$

Hence,

$$\frac{m}{BQ} = \frac{[M]}{\left[ML^0T^{-2}A^{-1}\right][TA]}$$

$$\frac{m}{BQ} = \frac{1}{\left[L^0T^{-1}A^0\right]}$$

$$\frac{m}{BQ} = [T]$$

$$\text{Time} = \frac{1}{\text{frequency}}$$

252. The velocity of light 'c', the constant of gravitation 'G' and Planck's constant 'h' be chosen as fundamental units, the dimensions of mass in terms of c, G and h is

(a) $\left[h^{1/2}c^{-3/2}G^{1/2}\right]$
(b) $\left[h^{1/2}c^{1/2}G^{-1/2}\right]$
(c) $\left[h^{1/2}c^{-5/2}G^{1/2}\right]$
(d) $\left[h^{1/2}c^{-1/2}G^{1/2}\right]$

TS EAMCET 09.05.2019, Shift-I
AP EAMCET -2014

Ans. (b) : We know that, dimensional formula of

Speed of light $[c] = [LT^{-1}]$

Gravitational constant $[G] = [M^{-1}L^3T^{-2}]$

Planck's constant $[h] = [ML^2T^{-1}]$

Let formula of mass in term of c, G and h be

$$M = c^x G^y h^z$$

$$[M] = [LT^{-1}]^x [M^{-1}L^3T^{-2}]^y [ML^2T^{-1}]^z$$

$$[M] = [M^{-y+z} L^{x+3y+2z} T^{-x-2y-z}]$$

where,

$-y + z = 1,\ x + 3y + 2z = 0,\ -x - 2y - z = 0$

On solving, we get

$$x = \frac{1}{2},\ y = -\frac{1}{2},\ z = \frac{1}{2}$$

So, dimension of $[M] = [h^{1/2}\, c^{1/2}\, G^{-1/2}]$

253. The pair with same dimension is _______

(a) Pressure and density
(b) Impulse and momentum
(c) Stress and strain
(d) Momentum and inertia

AP EAMCET-24.09.2020, Shift-I
DCE-2009

Ans. (b) : The dimension of Pressure is $[M^1L^{-1}T^{-2}]$.
The dimension of Density is $[M^1L^{-3}T^0]$.
The dimension of Impulse is $[M^1L^1T^{-1}]$.
The dimension of Momentum is $[M^1L^1T^{-1}]$.
The dimension of Stress is $[M^1L^{-1}T^{-2}]$.
The dimension of Strain is $[M^0L^0T^0]$.
The dimension of Inertia is $[M^1L^2T^0]$.
So, the pair with same dimension is 'Impulse and Momentum'.

254. The pair of physical quantities having the same dimensional formula is

(a) energy and torque
(b) torque and entropy
(c) entropy and power
(d) power and angular momentum

EAMCET-1991

Ans. (a) : Dim. of Torque = $[M\,L^2T^{-2}]$
Dim. Angular moment = $[M\,L^2T^{-1}]$
Dim. of Power = $[M\,L^2T^{-3}]$
Dim. of Entropy = $[M\,L^2\,T^{-2}\,K^{-1}]$
Dim. of energy = $[M\,L^2T^{-2}]$
Hence, from above dimensional formula we can see that dim. of Torque and energy are same.

255. The ratio L/R, where L and R stand for inductance and resistance, has the same dimensions as those of

(a) velocity
(b) acceleration
(c) time
(d) force

EAMCET-1994

@apna_pdf

Ans. (c) :

Dimensions of $\frac{[L]}{[R]} = \frac{[ML^2T^{-2}A^{-2}]}{[ML^2T^{-3}A^{-2}]}$

$= \left[M^0L^0T^1A^0\right]$

$= [T]$

So, The ratio of L/R has the same dimensions of time.

256. The pair of physical quantities not having the same dimensional formula is

(a) acceleration, gravitational field strength
(b) torque, angular momentum
(c) pressure, modulus of elasticity
(d) All of the above

EAMCET-1993

Ans. (b) : (a) Dimension of acceleration =
Dim. of gravitational field strength = $[LT^{-2}]$
(b) Dim. of torque = $[ML^2T^{-2}]$
Dim of angular momentum = $[M L^2T^{-1}]$
(c) Dim. of pressure = dim. of modulus of elasticity = $[M L^{-1}T^{-2}]$

257. If time period t of a drop of liquid of density d vibrating under surface tension s is given by the formula t = $\sqrt{d^ar^bs^c}$ where r is radius of drop a = 1 and c = –1, the value of b is

(a) 3
(b) –3
(c) –4
(d) 4

EAMCET-1993

Ans. (a) : Given that,

$t = \sqrt{d^ar^bs^c}$,

When a = 1, c = –1

Or $t = (d^ar^bs^c)^{1/2} = d^{1/2}r^{b/2}s^{-1/2}$ .... (i)

dim of d = ML^{-3}
dim of r = L
dim of s = MT^{-2}

Putting the values in equation (i),

$$[T] = \left[ML^{-3}\right]^{1/2}[L]^{b/2}\left[MT^{-2}\right]^{-1/2}$$

$$[T] = \left[M^0L^{-3/2+b/2}T^1\right]$$

$$\left[M^0L^0T^1\right] = \left[M^0L^{-3/2+b/2}T^1\right]$$

On comparing we have,

$$-\frac{3}{2}+\frac{b}{2} = 0$$

$$\frac{b}{2} = \frac{3}{2}$$

b = 3

258. Dimensions of ohm are same as (h = Planck's constant, e = charge)

(a) $\frac{h}{e}$
(b) $\frac{h^2}{e}$
(c) $\frac{h}{e^2}$
(d) $\frac{h^2}{e^2}$

EAMCET-1998

Ans. (c) : Ohm $[\Omega] = [M L^2A^{-2} T^{-3}]$

h = $[M L^2T^{-1}]$

e = [AT]

Dimension of given option are-

(a) $\frac{h}{e} = \frac{\left[ML^2T^{-1}\right]}{[AT]} = \left[ML^2A^{-1}T^{-2}\right]$

(b) $\frac{h^2}{e} = \frac{\left[ML^2T^{-1}\right]^2}{[AT]} = \left[M^2L^4A^{-1}T^{-3}\right]$

(c) $\frac{h}{e^2} = \frac{\left[ML^2T^{-1}\right]}{\left[A^2T^2\right]} = \left[ML^2A^{-2}T^{-3}\right]$

(d) $\frac{h^2}{e^2} = \frac{\left[ML^2T^{-1}\right]^2}{\left[A^2T^2\right]} = \left[M^2L^4A^{-2}T^{-4}\right]$

Hence, dimension of ohm is as same as dimension of $\frac{h}{e^2}$.

259. Which of the following has no dimensions?

(a) Angular velocity
(b) Momentum
(c) Angular momentum
(d) Strain

EAMCET-1995

Ans. (d) : Strain is defined as

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

$$= \frac{\left[M^0L^1T^0\right]}{\left[M^0L^1T^0\right]}$$

Dim. [strain] = $[M^0 L^0 T^0]$

So, strain is dimensionless quantity.

260. The dimension of resistance × capacitance are same as for

(a) frequency
(b) energy
(c) time period
(d) current

EAMCET-1995

Ans. (c) : Dimension of resistance × capacitance

$= [M L^2 T^{-3} I^{-2}] \times [M^{-1} L^{-2} T^4 I^2]$

$= [M^0 L^0 T^1 I^0]$

= dim. of time period

261. The velocity of a body falling freely under gravitational field varies as g^ph^q, where g is gravitational acceleration and h is height from which the body is released. p and q are given by

(a) p = 2 : q = 1/2
(b) p = 1/2 : q = 1/2
(c) p = 1/2 : q = 1
(d) p = q = 1

EAMCET-1994

@apna_pdf

Ans. (b) : According to the question,

$$v = g^p h^q$$

or $[L T^{-1}] = [LT^{-2}]^p [L]^q$

$[L T^{-1}] = [L^{p+q} T^{-2p}]$

Comparing both side,

$$-2p = -1 \Rightarrow p = \frac{1}{2}$$

$$p + q = 1 \Rightarrow q = \frac{1}{2}$$

So, p and q are $\frac{1}{2}$ and $\frac{1}{2}$.

262. The fundamental physical quantities that have same dimensions in the dimensional formula of torque and angular momentum are

(a) mass, time (b) time, length

(c) mass, length (d) time, mole

EAMCET-2000

Ans. (c) : Angular momentum = mvr

$= [M L T^{-1}] [L]$

$= [M L^2 T^{-1}]$

Torque $= F \times d$

$= [M L T^{-2}] [L]$

$= [M L^2 T^{-2}]$

So, from the dimension of torque and angular momentum the dimension of mass and length are same.

263. If pressure p, velocity v and time T are taken as fundamental physical quantities the dimensional formula of the force is

(a) $[pv^2T^2]$ (b) $[p^{-1}v^2T^{-2}]$

(c) $[pvT^2]$ (d) $[p^{-1}vT^2]$

EAMCET-2000

Ans. (a) : If pressure p, velocity v and time T are taken as fundamental physical quantity then dimension of

$F = p^\alpha v^\beta T^\gamma$ ....(i)

Or $[M L T^{-2}] = [M L^{-1} T^{-2}]^\alpha [LT^{-1}]^\beta [T]^\gamma$

$[M L T^{-2}] = [M^\alpha L^{-\alpha+\beta} T^{-2\alpha+\gamma-\beta}]$

On comparing we have,

$\alpha = 1$

$-\alpha + \beta = 1 \Rightarrow \beta = 2$

$-\beta - 2\alpha + \gamma = -2 \Rightarrow \gamma = 2$

Hence, $\alpha = 1, \beta = 2, \gamma = 2$

Putting the value of a, b, γ in equation (i),

$F =[p^1 v^2 T^2]$

$F = [p v^2 T^2]$

264. If C, R, L and I denote capacity, resistance, inductance and electric current respectively, the quantities having the same dimensions of time are

(1) [CR] (2) $\left[\frac{L}{R}\right]$

(3) $\left[\sqrt{LC}\right]$ (4) $[LI^2]$

(a) (1) and (2) only (b) (1) and (3) only

(c) (1) and (4) only (d) (1), (2) and (3) only

EAMCET-2006

Ans. (d) :

$\because$ Electrical Capacity (C) = $\dfrac{\text{Charge}}{\text{Potential difference}}$

Dimensional formula of charge,

$Q = [AT]$

Dimensional formula of electric potential,

$\Delta V = [ML^2T^{-3}A^{-1}]$

$\therefore$ Electric capacity = $\dfrac{[AT]}{[ML^2T^{-3}A^{-1}]}$

$C = [M^{-1}L^{-2}T^4A^2]$ ....(i)

Similarly, Voltage (V) = RI

$$R = \frac{V}{I} = \frac{(W/Q)}{I} = \frac{W}{Q.I} = \frac{[ML^2L^{-2}]}{[AT][A]} = [ML^2T^{-3}A^{-2}]$$

$R = [ML^2T^{-3}A^{-2}]$ ...(ii)

Similarly, Inductance (I) = $[ML^2T^{-2}A^{-2}]$ ...(iii)

and current (I) = $[M^0L^0T^0A^{-1}]$ ... (iv)

- for, $[CR] = [M^{-1}L^{-2}T^4A^2][ML^2T^{-3}A^{-2}] = [T^1]$

= dimension of time ....(1)

- $\dfrac{L}{R} = \dfrac{[ML^2T^{-2}A^{-2}]}{[ML^2T^{-3}A^{-2}]} = [T^1]$

= dimension of time ....(2)

- $\sqrt{LC} = \sqrt{[ML^2T^{-2}A^{-2}][M^{-1}L^{-2}T^4A^2]} = \sqrt{[T^2]} = [T]$

= dimension of time ....(3)

- $[LI^2] = [ML^2T^{-2}A^{-2}] [A^2]$

$= [ML^2T^{-2}A^{\circ}]$ ....(4)

So, equation (1), (2) and (3) gives the dimension of time.

265. Name of units of some physical quantities are given in Column I and their dimensional formulae are given in Column II. Match the following Columns and choose the correct answer.

Column I		Column II	
(A)	Pa-s	(1)	$[L^2T^{-2}K^{-1}]$
(B)	Nm-K^{-1}	(2)	$[MLT^{-3}K^{-1}]$
(C)	J kg^{-1} K^{-1}	(3)	$[ML^{-1}T^{-1}]$
(D)	Wm^{-1} K^{-1}	(4)	$[ML^2T^{-2}K^{-1}]$

Codes:

	(A)	(B)	(C)	(D)
(a)	(4)	(3)	(1)	(2)
(b)	(3)	(2)	(4)	(1)
(c)	(3)	(1)	(4)	(2)
(d)	(3)	(4)	(1)	(2)

EAMCET-2005

Ans. (d) :

(A) $\text{Pa}-\text{s} = \dfrac{N}{m^2}\cdot s = [ML^{-1}T^{-2}][T^1] = [ML^{-1}T^{-1}]$

(B) $\text{Nm}\,K^{-1} = [MLT^{-2}][L][K^{-1}] = [ML^2T^{-2}K^{-1}]$

(C) $\text{JKg}^{-1}K^{-1} = [ML^2T^{-2}][M^{-1}][K^{-1}] = [M^0L^2T^{-2}K^{-1}]$

(D) $\text{Wm}^{-1}K^{-1} = [M^1L^2T^{-3}]\,[L^{-1}][K^{-1}] = [MLT^{-3}K^{-1}]$

@apna_pdf

266. The position of a particle at time t is given by the equation $x(t) = \frac{v_0}{A}\left(1 - e^{\mu}\right)$
v_0 = constant and A > 0
Dimensions of v_0 and A respectively are
(a) $[M^0LT^0]$ and $[M^0L^0T^{-1}]$
(b) $[M^0LT^{-1}]$ and $[M^0LT^{-2}]$
(c) $[M^0LT^{-1}]$ and $[M^0L^0T]$
(d) $[M^0LT^{-1}]$ and $[M^0L^0T^{-1}]$

EAMCET-2004

Ans. (d) : Given,

$$x(t) = \frac{v_o}{A}(1 - e^{\mu})$$

According to the question v_o is constant and A > 0.
Since, e is constant so it should be unit less.
So, unit of A = $\sec^{-1} = [T^{-1}]$
x is length, so unit of x is meter.
$v_o = xA$
$v_o = \text{m sec}^{-1}$
$v_o = [LT^{-1}]$ or $[M^0 L T^{-1}]$
and $A = [T^{-1}]$ or $[M^0L^0T^{-1}]$

267. The Van Der Waals' equation for a gas is

$$\left(p + \frac{a}{V^2}\right)(V - b) = nRT$$

where p, V, R, T and n represent the pressure, volume, universal gas constant, absolute temperature and number of moles of a gas respectively, where a and b are constants. The ratio $\frac{b}{a}$ will have the following dimensional formula
(a) $[M^{-1}L^{-2}T^2]$
(b) $[M^{-1}L^{-1}T^{-1}]$
(c) $[ML^2T^2]$
(d) $[MLT^{-2}]$

EAMCET-2002

Ans. (a) : $\left(P + \frac{a}{V^2}\right)(V - b) = nRT$

According to homogeneity principle dimension of $\frac{a}{v^2}$ should be equal to dimension of P and dimension of b should be equal to volume V.

Thus $\frac{a}{v^2}$ = pressure
a = pressure × V^2
and b = Volume

$$\frac{b}{a} = \frac{\text{Volume}}{\text{Pressure} \times V^2}$$

$$\left[\frac{b}{a}\right] = \frac{[\text{Volume}]}{[\text{Pressure}][\text{Volume}]^2}$$

$$= \frac{[L^3]}{[ML^{-1}T^{-2}][L^3]^2} = \frac{1}{[ML^{-1}T^{-2}][L^3]} = \frac{1}{ML^2T^{-2}}$$

$$\left[\frac{b}{a}\right] = [M^{-1}L^{-2}T^2]$$

268. The energy (E), angular momentum (L) and universal gravitational constant (G) are chosen as fundamental quantities. The dimensions of universal gravitational constant in the dimensional formula of Planck's constant (h) is
(a) zero
(b) –1
(c) $\frac{5}{3}$
(d) 1

EAMCET-2008

Ans. (a) : We know that
Planck's constant, h ∝ E, L, G

$$h \propto E^a L^b G^c$$

Where E = energy, L = angular momentum
G = gravitational constant
Now, write it in their dimension

$$[ML^2T^{-1}] = [ML^2T^{-2}]^a [ML^2T^{-1}]^b [M^{-1}L^3T^{-2}]^c$$

$$[ML^2T^{-1}] = M^{(a+b-c)} L^{2a+2b+3c} T^{-2a-b-2c}$$

On comparing

$$a + b - c = 1$$
$$2a + 2b + 3c = 2$$
$$-2a - b - 2c = -1$$

On solving these equation
We get, $a = 0, b = 1, c = 0$
So, dimensions of universal gravitational constant is zero. i.e. $[h] = [E^0L^1G^0] \Rightarrow c = 0$

269. Dimension of force is
(a) $[M^2L^1T^{-1}]$
(b) $[M^1L^1T^{-2}]$
(c) $[M^2L^{-1}T^{-2}]$
(d) $[M^1L^1T^{-1}]$

JIPMER-2018
J&K CET- 2008

Ans. (b) : Dimension of force
Force = mass × acceleration

$$\text{Unit} = [\text{Kg}]\left[\frac{\text{meter}}{\text{sec}^2}\right]$$

Dimension of force = $[M^1L^1T^{-2}]$

270. Force is given by the expression F = A cos(Bx) + C cos(Dt) where x is displacement and t is time. The dimension of $\left(\frac{D}{B}\right)$ is same as that of
(a) Velocity
(b) Velocity gradient
(c) Angular velocity
(d) Angular momentum

TS EAMCET (Engg.)-2016

Ans. (a) : Given expression, F = A cos(Bx) + C cos(Dt)
Where [Bx] and [Dt] both are dimensionless and x is a displacement (in meter) and t is time (in second)
Hence,

$$\text{dimension of B} = \left[\frac{1}{x}\right] = \left[\frac{1}{L}\right] = [L^{-1}]$$

$$\text{dimension of D} = \left[\frac{1}{t}\right] = \left[\frac{1}{T}\right] = [T^{-1}]$$

@apna_pdf

$\therefore$ The ratio of $\frac{[D]}{[B]} = \frac{[T^{-1}]}{[L^{-1}]} = [LT^{-1}]$

and velocity unit is m/sec so the its dimension will be $[LT^{-1}]$

[D/B] dimension will be same as the dimension of velocity

271. Force F is given by the equation $\frac{X}{\text{Linear density}}$.Then dimension of X are

(a) $[M^2L^0T^{-2}]$
(b) $[M^0L^0T^{-1}]$
(c) $[L^2T^{-2}]$
(d) $[M^0L^2T^{-2}]$

TS EAMCET (Engg.)-2015

Ans. (a) : Given,

Equation is $F = \frac{X}{\text{linear density}}$ ...... (i)

$\because$ unit of linear density = Kg/m

dimension of linear density = ML^{-1}

dimension of force =[MLT^{-2}]

From eq. (i)

$$F = \frac{x}{\text{linear density}}$$

$$x = [F] \times \left[\frac{Kg}{m}\right]$$

$$= [MLT^{-2}]\left[\frac{M}{L}\right]$$

$$= [M^2L^0T^{-2}]$$

272. Dimensional formula for coefficient of restitution

(a) MLT^{-2}
(b) $M^0L^0T^0$
(c) MLT^{-1}
(d) MT^{-2}

TS EAMCET(Medical)-2015

Ans. (b) :

Coefficient of restitution (e) = $\frac{\text{Final velocity}}{\text{Initial velocity}}$

$\because$ coefficient of restitution, is the ratio is same dimensional quantity.

Hence, the dimension of coefficient of restitution is dimensionless $[M^0L^0T^0]$

273. Of the following quantities, which one has dimensions different from the remaining three?

(a) Energy per unit volume
(b) Force per unit area
(c) Product of voltage and charge per unit volume
(d) Angular momentum

[AIPMT 1989]

Ans. (d) : Energy per unit volume

$$\frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$$

Force per unit Area = $\frac{F}{A}$

$$= \frac{[MLT^{-2}]}{[L^2]}$$

$$= [ML^{-1}T^{-2}]$$

Product of voltage and charge per unit volume

$$= \frac{vit}{V}$$

$$= \frac{P \times t}{V} = \frac{[ML^2T^{-3}][T]}{[L^3]}$$

$$= [ML^{-1}T^{-2}]$$

Dimension of angular momentum

$$= (r)\ (P)$$
$$= (r)\ (mv)$$
$$= [L]\ [M]\ [LT^{-1}]$$
$$= [ML^2T^{-1}]$$

So, concluding we can say that angular momentum has different units.

274. Which of the following is a dimensional constant ?

(a) Relative density
(b) Poisson's ratio
(c) Refractive index
(d) Gravitational constant

[AIPMT 1995]

Ans. (d) : Gravitational constant is a dimensional constant.

$$\because \quad F = G.\frac{m_1m_2}{r^2}$$

$$\because \quad G = \frac{Fr^2}{m_1m_2}$$

The dimension of (F) = $[MLT^{-2}]$

The dimension of (r^2)= $[L^2]$

The dimension of m_1m_2 = $[M^2]$

The dimension of G = $\frac{[MLT^{-2}].[L^2]}{[M^2]}$

$$= [M^{-1}L^3T^{-2}]$$

275. Turpentine oil is flowing through a tube of length l and radius r. The pressure difference between the two ends of the tube is p. The viscosity of oil is given by $\eta = \frac{p(r^2 - x^2)}{4vl}$ where, v is the velocity of oil at distance x from the axis of the tube. The dimensions of η are

(a) $[M^0L^0T^0]$
(b) $[MLT^{-1}]$
(c) $[ML^2T^{-2}]$
(d) $[ML^{-1}T^{-1}]$

[AIPMT 1993]

@apna_pdf

Ans. (d) : Given,

$$\eta = \frac{P\left(r^2 - x^2\right)}{4vl}$$

Where,

P = Pressure difference
r = radius
l = length
v = velocity
x = distance

The dimension of P = $[ML^{-1}T^{-2}]$
The dimension of $(r^2 - x^2) = [L^2]$
The dimension of velocity = $[LT^{-1}]$
The dimension of distance = [L]

$$[\eta] = \frac{[P][r^2 - x^2]}{[v][L]} \Rightarrow [\eta] = \frac{\left[ML^{-1}T^{-2}\right]\left[L^2\right]}{\left[LT^{-1}\right][L]}$$

$$[\eta] = \frac{\left[ML^1T^{-2}\right]}{\left[L^2T^{-1}\right]} = \left[ML^{-1}T^{-1}\right]$$

276. The time dependence of physical quantity p is given by p = p_0 exp $(-\alpha t^2)$, where α is a constant and t is the time. The constant α

(a) is dimensionless
(b) has dimensions of $[T^{-2}]$
(c) has dimensions of $[T^2]$
(d) has dimensions of p

Ans. (b) : Given equation,

$p = p_0 \exp(-\alpha t^2)$,

Where αt^2 = dimensionless

$\alpha t^2 = [M^0L^0T^0]$

$$\alpha = \frac{1}{t^2} = \frac{1}{\left[T^2\right]}$$

$\alpha = [T^{-2}]$

277. According to Newton, the viscous force acting between liquid layers of area A and velocity gradient $\frac{\Delta v}{\Delta z}$ is given by $F = -\eta A\frac{dv}{dz}$, where η is constant called coefficient of viscosity. The dimensional formula of η is

(a) $[ML^{-2}T^{-2}]$ (b) $[M^0L^0T^0]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$

[AIPMT 1990]

Ans. (d) : Given,

$$F = -\eta A\frac{dv}{dz}$$

where η is coefficient of viscosity
The dimensions of F = $[MLT^{-2}]$
The dimensions of A = $[L^2]$
The dimensions of dz = [L]
The dimensions of dv = $[LT^{-1}]$
$\therefore$ The dimensions of η

$$= \frac{\left[MLT^{-2}\right][L]}{\left[L^2\right]\left[LT^{-1}\right]} = \frac{\left[ML^2T^{-2}\right]}{\left[L^3\right]\left[T^{-1}\right]}$$

$\eta = [ML^{-1}T^{-1}]$

278. The dimensional formula of torque is

(a) $[ML^2T^{-2}]$ (b) $[MLT^{-2}]$
(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-2}T^{-2}]$

UPCPMT-2014
[AIPMT 1989]

Ans. (a) : Torque
$\tau = F.r$
Where F = torque
r = distance of force form the center
Dimensions of r and F are [r] = [L] and [F] = $[MLT^{-2}]$
$[\tau] = [MLT^{-2}]\,[L]$
$[\tau] = [ML^2T^{-2}]$

279. Which of the following will have the dimensions of time?

(a) [LC] (b) $\left[\frac{R}{L}\right]$
(c) $\left[\frac{L}{R}\right]$ (d) $\left[\frac{C}{L}\right]$

[AIPMT 1996]

Ans. (c) : [RC] = [T] Time constant of R – C circuit.

$\left[\frac{L}{R}\right] = [T]$ Time constant of R – L circuit

Hence, option (c) is correct.

280. The force F on a sphere of radius r moving in a medium with velocity v is given by F = $6\pi\eta rv$. The dimensions of η are

(a) $[ML^{-3}]$ (b) $[MLT^{-2}]$
(c) $[ML^{-1}]$ (d) $[ML^{-1}T^{-1}]$

[AIPMT 1997]

Ans. (d) : Given,

$F = 6\pi\eta rv$

$$\eta = \frac{F}{6\pi rv}$$

The dimension of F = $[MLT^{-2}]$
The dimension of r = [L]
The dimension of v = $[LT^{-1}]$

$$\therefore \quad \eta = \frac{[MLT^{-2}]}{[L][LT^{-1}]}$$

$\eta = [ML^{-1}T^{-1}]$

281. A pair of physical quantities having same dimensional formula is

(a) force and torque
(b) work and energy
(c) force and impulse
(d) linear momentum and angular momentum

[AIPMT 2000]

Ans. (b) : A pair of physical quantities having same dimensional formula is –
work and energy.
The dimension of work = Fd cos θ
= $[MLT^{-2}]\,[L]$
= $[ML^2T^{-2}]$
The dimension of energy $E = m.c^2$
$E = [M][L^1T^{-1}]^2$
$E = [ML^2T^{-2}]$

@apna_pdf

282. The ratio of the dimensions of Planck's constant and that of the moment of inertia is the dimension of

(a) frequency (b) velocity
(c) angular momentum (d) time

SRM JEE-2010
[AIPMT 2005]

Ans. (a) : Dimension of Planck's constant,

$$h=\frac{E}{\nu}=\frac{\left[ML^2T^{-2}\right]}{\left[M^0L^0T^{-1}\right]}=[ML^2T^{-1}]$$

Dimension of moment of Inertia = mass × (Radius of gyration)^2

$$=[M^1L^0T^0]\times[M^0L^1T^0]^2=[ML^2]$$

The ratio of the dimensions,

$$=\frac{[ML^2T^{-1}]}{[ML^2]}$$

$$=[T^{-1}]$$

T^{-1} is the dimension of frequency.

283. The velocity υ of a particle at time t is given by $\upsilon=at+\dfrac{b}{t+C}$, where a, b and c are constants. The dimensions of a b, and c are respectively

(a) $[LT^{-2}]$,[L] and [T] (b) $[L^2]$,[T] and $[LT^2]$
(c) $[LT^2]$,[LT] and [L] (d) [L],[LT] and $[T^2]$

AP EMCET(Medical)-2011
[AIPMT 2006]

Ans. (a) : Given,

$$v=at+\frac{b}{t+c}$$

The dimension of v = The dimension of a.t = the dimension of $\dfrac{b}{t+c}$

Then,

The dimension of v = dimension of a.t

$$[LT^{-1}]=a.t$$

$$a=\frac{[LT^{-1}]}{[T]}$$

The dimension of a = $[LT^{-2}]$

The dimension of b = [V] [T]

$=[LT^{-1}]$ [T]

= [L]

The dimension of c = [T]

Hence, option (a) is correct.

284. Which two of the following five physical parameters have the same dimensions?

(i) Energy density
(ii) Refractive index
(iii) Dielectric constant
(iv) Young's modulus
(v) Magnetic field

(a) (ii) and (iv) (b) (iii) and (v)
(c) (i) and (iv) (d) (i) and (v)

[AIPMT 2008]

Ans. (c) :

	Physical parameter		**Dimensions**
(i)	Energy density	-	$[ML^{-1}T^{-2}]$
(ii)	Refractive index	-	$[M^0L^0T^0]$
(iii)	Dielectric constant	-	$[M^0L^0T^0]$
(iv)	Young's modulus	-	$[ML^{-1}T^{-2}]$
(v)	Magnetic field	-	$[MA^{-1}T^{-2}]$

Hence, Energy density and Young's modulus has the same dimension.

285. If the dimensions of a physical quantity are given by $[M^a\ L^b\ T^c]$, then the physical quantity will be

(a) pressure if a = 1,b = −1,c = −2
(b) velocity if a =1, b =0, c = −1
(c) acceleration if a =1, b =1, c = −2
(d) force if a =0, b = −1, c = −2

[AIPMT 2009]

Ans. (a) : We know that-

$$P=\frac{F}{A}$$

Where, P = Pressure
F = Force
A = Area

$$\therefore\quad P=\frac{[MLT^{-2}]}{[L^2]}\qquad\left(\because\ F=[MLT^{-2}]\right)$$

or $P=[ML^{-1}T^{-2}]$

The value of a, b and c are 1, –1 and –2 respectively.

$$\because\quad V=\frac{S}{t}$$

Where, v = velocity
s = displacement
t = time

$$\therefore\quad V=\frac{[L]}{[T]}$$

$$v=[M^0LT^{-1}]$$

Here, a = 0, b = 1 and c = –1

$$\because\quad a=\frac{v}{t}$$

Where a = acceleration
v = velocity
t = time

$$\therefore\quad a=\frac{[LT^{-1}]}{[T]}$$

or

$$a=[M^0LT^{-2}]$$

Here, a = 0, b =1 and c = –2

$\because$ F = ma

Where,
F = force
m = Mass
a = Acceleration

$\therefore$ F = [M] $[LT^{-2}]$

or F = $[MLT^{-2}]$

Here, a = 1, b = 1 and c = –2

@apna_pdf

286. The dimensions of $\frac{1}{2}\varepsilon_0E^2$ E^2, where ε_0 is permittivity of free space and E is electric field, are

(a) $[ML^2T^{-2}]$ (b) $[ML^{-1}T^{-2}]$
(c) $[ML^2T^{-1}]$ (d) $[MLT^{-1}]$

[AIPMT 2010]
AIIMS-2014

Ans. (b) : The given equation is $\frac{1}{2}\varepsilon_0E^2$

Where,

ε_0 = permittivity
E = Electric field

$\because$ Dimension of $\varepsilon_0 = [M^{-1}L^{-3}T^4A^2]$
and

Dimension of electric field $E = \frac{F}{q}$

$$E = \frac{[MLT^{-2}]}{[AT]}$$

$$E = [MLT^{-3}A^{-1}]$$

$\therefore$ Dimension of $\frac{1}{2}\varepsilon_0E^2 = [M^{-1}L^{-3}T^4A^2]\,[MLT^{-3}A^{-1}]^2$

$$\frac{1}{2}\varepsilon_0E^2 = [M^{-1}L^{-3}T^4A^2]\,[M^2L^2T^{-6}A^{-2}]$$

$$\frac{1}{2}\varepsilon_0E^2 = [ML^{-1}T^{-2}]$$

287. The dimensions of $(\mu_0\,\varepsilon_0)^{-1/2}$ are

(a) $[L^{1/2}T^{-1/2}]$ (b) $[L^{-1}T]$
(c) $[LT^{-1}]$ (d) $[L^{1/2}T^{1/2}]$

Assam CEE-2020
[AIPMT 2012]

Ans. (c) : We know that,

Velocity of electromagnetic wave $(c) = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

Then, $(\mu_0\varepsilon_0)^{-1/2}$ have same dimension of velocity is $[LT^{-1}]$

288. If dimensions of critical velocity V_c of a liquid flowing through a tube are expressed as $[\eta^x\rho^yr^z]$ r , where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by

(a) 1, –1, –1 (b) –1, –1, 1
(c) –1, –1, –1 (d) 1, 1, 1

[AIPMT 2015]

Ans. (a) : We know that,

$$[V_c] = [M^0LT^{-1}]$$

$$\eta = \frac{F\times r}{A\times v}$$

$$[\eta] = \frac{[MLT^{-2}]\times[L]}{[L^2]\times[LT^{-1}]}$$

$$[\eta] = [ML^{-1}T^{-1}]$$

$$\rho = \frac{\text{Mass}[M]}{\text{Volume}[L^{-3}]}$$

$$[\rho] = [ML^{-3}]$$

$$[r] = [L]$$

We have given that the critical velocity is given as,

$$V_c = [\eta^x\rho^yr^z]$$

$$[M^0LT^{-1}] = [ML^{-1}T^{-1}]^x[ML^{-3}]^y[L]^z$$

$$[M^0LT^{-1}] = [M^{x+y}L^{-x-3y+z}T^{-x}]$$

Now, comparing the power of M, L and T on the both sides, we get

For M, $M^0 = M^{x+y}$
$x = -y$
For T, $T^{-1} = T^{-x}$
$-1 = -x$
$x = 1,\ y = -1$
For L, $L^1 = L^{-x-3y+z}$
$1 = -1 + 3 + z$
$z = -1$

So,
$x = 1$, $y = -1, -1$

289. If energy (E), velocity (v) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be

(a) $[Ev^{-2}T^{-1}]$ (b) $[Ev^{-1}T^{-2}]$
(c) $[Ev^{-2}T^{-2}]$ (d) $[E^{-2}v^{-1}T^{-3}]$

[AIPMT 2015]
AP EAMCET(Medical)-2009

Ans. (c) : We know that,

Surface Tension $[T] = \frac{\text{Force}}{\text{Length}}$

$$[T] = \frac{\text{Mass}\times\text{Acceleration}}{\text{Length}} \text{ .... (i)}$$

and Energy $(E) = \frac{1}{2}mv^2$

$$m = \frac{E}{v^2}\times 2$$

$[M] = [Ev^{-2}]$
Now, in equation (i)

$$[T] = \frac{[Ev^{-2}][LT^{-2}]}{[L]}$$

$$[T] = [Ev^{-2}T^{-2}]$$

290. The physical quantity that has the same dimensional formula as pressure is:

(a) Force
(b) Momentum
(c) Young's modulus of elasticity
(d) Coefficient of viscosity

@apna_pdf

Ans. (c) : Given,

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$P = \frac{\left[MLT^{-2}\right]}{\left[L^2\right]}$$

$$P = \left[ML^{-1}T^{-2}\right]$$

We know,

$$\text{Young's Modulus } [Y] = \frac{\text{Stress}}{\text{Strain}}$$

$$Y = [ML^{-1}T^{-2}]$$

Then, strain have no dimension. Only stress have dimension . The Young's modulus also have same dimension as stress and stress have same dimension as pressure. So, Young's modulus will have same dimension formula as pressure.

291. Match list-I with List-II

	List-I		List-II
(a)	Gravitational constant	(i)	$[L^2T^{-2}]$
(b)	Gravitational potential energy	(ii)	$[M^{-1}L^3T^{-2}]$
(c)	Gravitational potential	(iii)	$[LT^{-1}]$
(d)	Gravitational intensity	(iv)	$[ML^2T^{-2}]$

Choose the correct answer from the options given below

(a) (a)-(ii), (b)-(iv), (c)-(iii), (d)-(i)
(b) (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)
(c) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)
(d) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

NEET 17.07.2022

Ans. (d) : (a) – (ii) , (b) – (iv), (c) – (i), (d) – (iii)

	List-I		List-II
A.	Gravitational constant	(ii)	$[M^{-1}L^3T^{-2}]$
B.	Gravitational Potential Energy	(iv)	$[ML^2T^{-2}]$
C.	Gravitational Potential	(i)	$[L^2T^{-2}]$
D.	Gravitational Intensity	(iii)	$[LT^{-1}]$

292. Plane angle and solid angle have

(a) No units and no dimensions
(b) Both units and dimensions
(c) Unit but no dimensions
(d) Dimensions but no units

NEET 17.07.2022

Ans. (c) : Unit but no dimensions

Plane angle	Radian
Solid angle	Steradian

293. The dimensions $[MLT^{-2}A^{-2}]$ belong to the

(a) Magnetic permeability
(b) Electric permittivity
(c) Magnetic flux
(d) Self inductance

NEET 17.07.2022

Ans. (a) :

List–I	List–II
(a) Magnetic Permeability	$[M^1LT^{-2}A^{-2}]$
(b) Electric Permeability	$[M^{-1}L^{-3}T^4A^2]$
(c) Magnetic flux	$[M^1L^2T^{-2}A^{-1}]$
(d) Self Inductance	$[ML^2T^{-2}A^{-2}]$

294. Match the following

A. Angular momentum	1. $\left[M^{-1}L^2T^{-2}\right]$
B. Torque	2. $\left[M^1T^{-2}\right]$
C. Gravitational constant	3. $\left[M^1L^2T^{-2}\right]$
D. Tension	4. $\left[M^1L^2T^{-1}\right]$

(a) C –2, D –1
(b) A –4, B –3
(c) A –3, C –2
(d) B –2, A –1

JIPMER-2014

Ans. (b) : Dimensional formula of angular momentum

angular momentum = mvr
= kg (m/s)m
$= [M][LT^{-1}]\,[L]$
$= [ML^2T^{-1}]$

Dimensional formula of Torque

Torque $\tau = F.r = ma.r$
$= \text{kg}\,(\text{m/s}^2)\text{m}$
$= [M]\,[LT^{-2}]\,[L] = [ML^2T^{-2}]$

Dimensonal formula of Gravitiational constant -

$$\text{Gravitational constant } (G) = \frac{F.r^2}{M_e.m}$$

$$= \frac{\left[MLT^{-2}\right]\left[L^2\right]}{[M][M]} = [M^{-1}L^3T^{-2}]$$

Dimensional formula of Tension -

Tension force = Gravity force = mg
$= \text{kg.}\,(\text{m/s}^2)$
$= [M]\,[LT^{-2}] = [MLT^{-2}]$

295. The Physical quantity having the dimensions $[M^{-1}\,L^{-3}\,T^3\,A^2]$ is

(a) Resistance
(b) Resistivity
(c) Electrical conductivity
(d) Electromotive force

JIPMER-2011

Ans. (c) : We know that,

$$\text{Resistivity } \rho = \frac{RA}{l}$$

$$\rho = \frac{\left[ML^2T^{-3}A^{-2}\right]\left[L^2\right]}{[L]}$$

$$\rho = \frac{[M]}{L^{-3}[AT][T]} = [ML^3A^{-2}\,T^{-3}]$$

So, Electrical conductivity $\sigma = \dfrac{1}{\rho}$

$$\rho = [ML^3A^{-2}T^{-3}]$$

$$\sigma = \frac{1}{\rho} \Rightarrow \sigma = [M^{-1}L^{-3}A^2T^3]$$

@apna_pdf

296. The potential energy of a particle varies with distance x from a fixed origin as $v=\left(\frac{A\sqrt{x}}{x+B}\right)$; where, A and B are constants. The dimensions of AB are

(a) $[ML^{5/2}T^{-2}]$ (b) $[ML^2T^{-2}]$

(c) $[M^{3/2}L^{3/2}T^{-2}]$ (d) $[ML^{7/2}T^{-2}]$

JIPMER-2010

Ans. (d) : Given , $v=\frac{A\sqrt{x}}{x+B}$ ....(i)

Dimensions of v = dimensions of potential energy

$= [ML^2T^{-2}]$

From equation (i)

Dimensions of B = dimensions of x = $[M^0LT^0]$

$\therefore$ Dimensions of A

$$=\frac{\text{dimensions of } v\times\text{dimensions of}(x+B)}{\text{dimensions of }\sqrt{x}}$$

$$=\frac{[ML^2T^{-2}]\,[M^0LT^0]}{[M^0L^{1/2}T^0]}=[ML^{5/2}T^{-2}]$$

Hence, dimensions of AB

$= [ML^{5/2}T^{-2}]\,[M^0LT^0] = [ML^{7/2}T^{-2}]$

297. In a system of units if force (F), acceleration (A), and time (T) are taken as fundamental units, then the dimensional formula of energy is :

(a) $[FA^2T]$ (b) $[FAT^2]$

(c) $[F^2AT]$ (d) $[FAT]$

JIPMER-2005

Ans. (b) : According to question energy in expressed as–

$$E \propto F^aA^bT^c \text{ .... (i)}$$

$$E = KF^aA^bT^c$$

Where K is dimensional constant.

Putting the dimensional formula of given parameters in the equation (i)

$\because$ $E=\left[ML^2T^{-2}\right],\ F=\left[MLT^{-2}\right], A=\left[LT^{-2}\right], T=\left[T\right]$

$\therefore$ $\left[ML^2T^{-2}\right]=K\left[MLT^{-2}\right]^a\left[LT^{-2}\right]^b\left[T\right]^c$

$\left[ML^2T^{-2}\right]=K\left[M^aL^{a+b}T^{-2a-2b+c}\right]$

On comparing both side –

$a=1,\ a+b=2,\ -2a-2b+c=-2$

Solving the above equation –

$a = 1, b = 1, c = 2$

Putting the value of a, b, c in equation (i)

$\therefore$ $[E]=\left[KF^1A^1T^2\right]$

$\because$ K is dimensionless hence, K = 1

$[E]=\left[F^1A^1T^2\right]$

298. The SI unit of a physical quantity is Pascal-second. The dimensional formula of this quantity will be:

(a) $[ML^{-1}T^{-1}]$ (b) $[ML^{-1}T^{-2}]$

(c) $[ML^2T^{-1}]$ (d) $[M^{-1}L^3T^0]$

JEE Main-27.06.2022, Shift-II

AFMC-2005

Ans. (a) : Let the quantity be x.

Then according to question, x = Pa × s.

$$x=\frac{N}{m^2}\times s$$

Dimensional formula of $x=\frac{\left[MLT^{-2}\right]}{\left[L^2\right]}\times\left[T\right]$

Dimensional formula of $x=\left[ML^{-1}T^{-1}\right]$

299. Let I, r, c, and v represent inductance, resistance, capacitance and voltage, respectively. The dimension of $\frac{I}{rcv}$ in SI units will be

(a) $\left[LT^2\right]$ (b) $\left[LTA\right]$

(c) $\left[A^{-1}\right]$ (d) $\left[LA^{-2}\right]$

JEE Main-12.01.2010, Shift-II

Ans. (c) : We know,

Time constant (t) in L-R circuit $=\frac{L}{R}$

Then, dimensional formula of $\frac{L}{R}$

$$\frac{L}{R}=[T]$$

And charge (q) = cv

Then, dimensional formula of cv

cv = [AT]

Now, dimensional formula of $\frac{I}{rcv}$

$$\frac{I}{rcv}=\left[\frac{T}{AT}\right]=\left[A^{-1}\right]$$

300. If e is the electronic charge, c is the speed of light in free space and h is Planck's constant, the quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}$ has dimensions of

(a) $\left[MLT^0\right]$ (b) $\left[MLT^{-1}\right]$

(c) $\left[M^0L^0T^0\right]$ (d) $\left[LC^{-1}\right]$

Ans. (c) :

Force (F) $=\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}\Rightarrow\frac{e^2}{4\pi\varepsilon_0}=Fr^2$

Energy (E) $=\frac{hc}{\lambda}\Rightarrow hc=E\lambda$

Now,

$$\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}=\frac{Fr^2}{E\lambda}$$

Dimension of $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}=\frac{\left[MLT^{-2}\right]\left[L^2\right]}{\left[ML^2T^{-2}\right]\left[L^1\right]}$

$=\left[M^0L^0T^0\right]$

@apna_pdf

301. The entropy of any system is given by

$$S = \alpha^2\beta\ln\left[\frac{\mu kR}{J\beta^2}+3\right]$$

Where, α and β are the constants; μ, J, k and R are number of moles, mechanical equivalent of heat, Boltzmann constant and gas constant, respectively. $\left[\text{Take, } S = \frac{dQ}{T}\right]$

Choose the incorrect option.

(a) α and J have the same dimensions.

(b) S, β, k and μR have the same dimensions.

(c) S and α have different dimensions.

(d) α and k have the same dimensions.

Ans. (d) : $S = \frac{d\theta}{T}$

$$[S] = \frac{[ML^2T^{-2}]}{[\theta]} = [ML^2T^{-2}\theta^{-1}]$$

$$[S] = [\alpha^2\beta] = [ML^2T^{-2}\theta^{-1}] \quad \ldots(i)$$

and $\frac{\mu kR}{J\beta^2} = \text{dimensionless} = [M^0L^0T^0] \quad \ldots(ii)$

$$[R] = \frac{[PV]}{[\mu T]} = \frac{[ML^2T^{-2}]}{[Mol][\theta]} = [ML^2T^{-2}mol^{-1}\theta^{-1}] \quad \ldots(iii)$$

J= Mechanical equivalent of heat = $[M^0L^0T^0]$= dimensionless

$$[k] = \frac{[Energy]}{[Temperature]} = [ML^2T^{-2}\theta^{-1}] \quad \ldots(iv)$$

From equation (ii),

$$[\mu kR] = [\beta^2]$$

$$[mol][ML^2T^{-2}\theta^{-1}][ML^2T^{-2}mol^{-1}\theta^{-1}] = [\beta^2]$$

$$[M^2L^4T^{-4}\theta^{-2}] = [\beta^2]$$

$$\Rightarrow [\beta] = [ML^2T^{-2}\theta^{-1}] \quad \ldots(v)$$

Now, From equation (i),

$$[\alpha^2][\beta] = [ML^2T^{-2}\theta^{-1}]$$

$$[\alpha^2] = \frac{[ML^2T^{-2}\theta^{-1}]}{[ML^2T^{-2}\theta^{-1}]}$$

$$[\alpha] = 1$$

$$[\alpha] = [M^0L^0T^0] = \text{dimensionless} \quad \ldots(iv)$$

Thus, options (a) (b) and (c) are correct. Therefore option (d) is incorrect.

302. If velocity [v], time [T] and force [F] are choosen as the base quantities, the dimensions of the mass will be

(a) $[FT^{-1}v^{-1}]$

(b) $[FTv^{-1}]$

(c) $[FT^2v]$

(d) $[FvT^{-1}]$

JEE Main-31.08.2021, Shift-II

[AIPMT 2014]

Ans. (b) : Let,

mass (m) $\propto F^a v^b T^c$ … (i)

$$m \propto [MLT^{-2}]^a[LT^{-1}]^b[T]^c$$

$$[M^1L^0T^0] \propto [M^aL^{a+b}T^{-2a-b+c}]$$

On comparing both side, we get

a = 1

a + b = 0 ⇒ 1 + b = 0 ⇒ b = –1

–2a – b + c = 0 ⇒ –2 × 1 – (–1) + c = 0, c = 1

On putting value of a, b & c in equation (i), we get

Dimension of m = $[F]^1 [v]^{-1} [T] = [F v^{-1} T]$

303. The expression below give current I through an electronic component as a function of applied potential V. I_o and V_o are constants having dimensions of current and potential respectively. Which of the following are dimensionally incorrect?

(a) $I = I_o\left(e^{\frac{2V}{V_o}}+1\right)$

(b) $I = I_o\left(e^{\frac{V}{2V_o}}-1\right)$

(c) $I = I_oV_o\left(e^{\frac{V}{V_o}}-1\right)$

(d) $I = I_o\left(\frac{V}{V})\right)\left(e^{\frac{V}{V_o}}-1\right)$

Ans. (c) : All the above options are dimensionally equivalent but option (c) is not equivalent.

Then,

Dimension of I = dimension of $I_oV_o\left(e^{\frac{V}{V_o}}-1\right)$

$[A] = [A]\,[ML^2T^{-3}A^{-1}]\,[M^0L^0T^0]$

$[A] = [ML^2T^{-3}]$

Hence, option (c) is not dimensionally equivalent.

304. The dimensional formula of $\frac{1}{2}\mu_0H^2$ (μ_0 = magnetic field intensity) is

(a) $[MLT^{-1}]$

(b) $[ML^2T^{-2}]$

(c) $[ML^{-1}T^{-2}]$

(d) $[ML^2T^{-1}]$

AP EAMCET -2011

Ans. (c) : $\frac{1}{2}\mu_0H^2$ is energy density of a magnetic field

Hence, its dimension is same as that of energy density.

$$\frac{1}{2}\mu_0H^2 = \frac{[ML^2T^{-2}]}{[L^3]}$$

$$= [ML^{-1}T^{-2}]$$

@apna_pdf

305. If E, M, J and G respectively denote energy, mass, angular momentum and universal gravitational constant, the quantity, which has the same dimensions as the dimensions of $\frac{EJ^2}{M^5G^2}$

(a) Time (b) Angle

(c) Mass (d) Length

AP EAMCET -2013

Ans. (b) : E = Energy = $[ML^2T^{-2}]$

M = Mass = [M]

J = Angular momentum $[M^1L^2T^{-1}]$

G = Universal gravitational constant $[M^{-1}L^3T^{-2}]$

$$\frac{EJ^2}{M^5G^2} = \frac{[ML^2T^{-2}][M^1L^2T^{-1}]^2}{[M]^5[M^{-1}L^3T^{-2}]^2}$$

$$= \frac{[ML^2T^{-2}][M^2L^4T^{-2}]}{[M^5][M^{-2}L^6T^{-4}]}$$

$$= [M^0L^0T^0]$$

$[M^0L^0T^0]$ is dimension of angle.

306. Match the List I with List II.

	List-I		List-II
A.	Boltzmann constant	I.	$[ML^0T^0]$
B.	Coefficient of viscosity	II.	$[ML^{-1}T^{-1}]$
C.	Water equivalent	III.	$[MLT^{-3}K^{-1}]$
D.	Coefficient of thermal conductivity	IV.	$[ML^2T^{-2}K^{-1}]$

The correct match in the following is

(a) A–III; B– I; C–II; D–IV

(b) A–III; B– II; C–I; D–IV

(c) A–IV; B– II; C–I; D–III

(d) A–IV; B– I; C–II; D–III

AP EAMCET -2016

Ans. (c) :

- Baltzman constant = $[ML^2T^{-2}K^{-1}]$
- Coefficient of viscosity = $\frac{MLT^{-2}}{[L^2 \times T^{-1}]} = [ML^{-1}T^{-1}]$
- Water equivalent = $[ML^{\circ}T^{\circ}]$
- Coefficient of thermal conductivity = $[MLT^{-3}K^{-1}]$

307. When light is refracted from a surface, which of its following physical parameters does not change?

(a) Velocity (b) Amplitude

(c) Frequency (d) Wavelength

WB JEE 2015

Ans. (c) : Frequency of the light depends upon the source so it does not change in case of reflection or refraction or polarization.

308. An object is moving through the liquid the viscous damping force acting on it' is proportional to the velocity. then dimensional formula of constant of proportionality is

(a) $[ML^{-1}T^{-1}]$ (b) $[MLT^{-1}]$

(c) $[ML^0LT^{-1}]$ (d) $[ML^0T^{-1}]$

UP CPMT-2009

Ans. (d) :

$F \propto V$

$F = LV$

$$L = \frac{F}{V} = \frac{[MLT^{-2}]}{[LT^{-1}]}$$

$= [ML^{\circ}T^{-1}]$

309. Number of particles is given by

$n = -D\frac{n_2 - n_1}{x_2 - x_1}$ crossing a unit area perpendicular to X-axis in unit time, where n_1 and n_2 are number of particles per unit volume. Find dimensions of D called as diffusion constant

(a) $[M^0LT^{-2}]$ (b) $[M^0L^2T^{-4}]$

(c) $[M^0LT^{-3}]$ (d) $[M^0L^2T^{-1}]$

UP CPMT-2014

Manipal UGET-2014

Ans. (d) : Given

Number of particles (n) = $-D\frac{n_2 - n_1}{x_2 - x_1}$

$n_1 = n_2$ = number of particles per unit volume = $[L^{-3}]$

So,

$$n = \frac{\text{Number of particles}}{A \times t} = \frac{[M^0L^0T^0]}{[L^2][T]} = [L^{-2}T^{-1}]$$

Now, from formula

$$[D] = \frac{[n][x_2 - x_1]}{[n_1 - n_2]} = \frac{[L^{-2}T^{-1}][L]}{[L^{-3}]} = [L^2T^{-1}]$$

310. The unit of viscosity in the CGS system is poise (P) and that in SI Poiseuille (PI). Which of the following statement is correct?

(a) 1 P = 1PI (b) 1P = 10PI

(c) 10P =1PI (d) Non of these

UP CPMT-2013

Ans. (c) : 1P = 1 gm cm^{-1} S^{-1}

$\therefore$ 1 PI = 10 g cm^{-1} S^{-1}

$\boxed{1PI = 10\ P}$

311. $[ML^3T^{-3}A^{-2}]$ is the dimensional formula of

(a) resistance (b) resistivity

(c) conductance (d) conductivity

UP CPMT-2012

@apna_pdf

Ans. (b) : The formula of resistivity is given by

$$\rho = \frac{AR}{l}$$

• Here, ρ is the resistivity of the wire A is Area of cross section- of wire R is the resistance of the wire.
l is the length of the wire.

The dimension of Resistivity $\rho = [ML^3T^{-3}A^{-2}]$

The dimension of Resistance $R = [ML^2T^{-3}A^{-2}]$

The dimension of Conductance $C = [M^{-1}L^{-2}T^3A^2]$

The dimension of Conductivity $= [M^{-1}L^{-2}T^3A^1]$

312. In the relation $p = \frac{\alpha}{\beta} e^{-\alpha z/k\theta}$ p is pressure, Z is distance, k is Boltzmann constant and θ is the temperature. The dimensional formula of β will be

(a) $[ML^2T]$
(b) $[M^0L^2T^0]$
(c) $[ML^0T^{-1}]$
(d) $[M^0L^2T^{-1}]$

UP CPMT-2011
BITSAT-2009

Ans. (b) : $p = \frac{\alpha}{\beta} e^{-\frac{\alpha z}{k\theta}}$

As we know that exponential term is dimensionless,

Dimension of α, $[\alpha] = \frac{[k][\theta]}{[z]}$

Where, k = Boltzmann constant
θ = Temperature
z = Distance

$$\alpha = \frac{[ML^2T^{-2}K^{-1}] \times [K]}{[L]}$$

$$\alpha = [MLT^{-2}]$$

$$[p] = \frac{[\alpha]}{[\beta]} \quad (\text{from equation})$$

$$\beta = \frac{[\alpha]}{[P]} = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]} = [L^2] \quad \text{or}$$

$$\beta = [M^0L^2T^0]$$

313. Velocity v is given by v = at^2 + bt + c, where t is time. What are the dimensions of a, b and c respectively ?

(a) $[LT^{-3}][LT^{-2}]\text{and}[LT^{-1}]$
(b) $[LT^{-1}],[LT^{-2}]\text{and}[LT^{-3}]$
(c) $[LT^{-2}],[LT^{-3}]\text{and}[LT^{-1}]$
(d) $[LT^{-1}],[LT^{-3}]\text{and}[LT^{-2}]$

UP CPMT-2010

Ans. (a) : Dimension of velocity are $[V] = [LT^{-1}]$

So, dimension of

$$[at^2] = [LT^{-1}]$$

$$[a][T^2] = [LT^{-1}]$$

$$[a] = [LT^{-3}]$$

Dimension of $[bt] = [LT^{-1}]$

$$[b] = [LT^{-2}]$$

Dimension of $[c] = [LT^{-1}]$

314. If $P = \frac{RT}{V-b} e^{-\alpha V/RT}$, then dimensional formula of α is

(a) P
(b) R
(c) T
(d) V

UP CPMT-2010

Ans. (a) : Given $P = e^{-\frac{\alpha V}{RT}} \frac{RT}{V-b}$

$\frac{\alpha V}{RT}$ should be dimensionless

$$[\alpha] = \frac{[RT]}{[V]} \_\_\_\text{(i)}$$

We know that $PV = nRT$

$$[P] = \frac{[nRT]}{[V]} \_\_\_\text{(ii)}$$

From equation (i) and (ii)

$$\alpha = P$$

315. If E = energy , G = gravitational constant, I = impulse and M = mass, then dimensions of $\frac{GIM^2}{E^2}$

(a) time
(b) mass
(c) length
(d) force

UP CPMT-2006

Ans. (a) : The dimensional formula of given equation is : -

$$\frac{GIM^2}{E^2} = \frac{[M^{-1}L^3T^{-2}][MLT^{-1}][M]^2}{[ML^2T^{-2}]^2}$$

$$= \frac{[M^2L^4T^{-3}]}{[M^2L^4T^{-4}]}$$

$$= [M^0L^0T^1]$$

So, it is clear that dimensions of $\frac{GIM^2}{E^2}$ are same as that of the time.

316. Dimensions of relative density is

(a) $[ML^{-2}]$
(b) $[ML^{-3}]$
(c) Dimensionless
(d) $[M^2L^{-6}]$

UP CPMT-2003

Ans. (c) : Relative density = $\frac{\text{Density of substance}}{\text{Density of water}}$

$$= \frac{[ML^{-3}]}{[ML^{-3}]}$$

Since, both have the same dimensions, thus their ratio is dimensionless.

@apna_pdf

317. The dimensional formula for emf, e in MKS system will be

(a) $[ML^2T^{-2}Q^{-1}]$ (b) $[ML^2T^{-1}]$
(c) $[ML^{-2}Q^{-1}]$ (d) $[MLT^{-2}Q^{-2}]$

UP CPMT-2002

Ans. (a) : Dimensional formula of emf electro magnetic force -

$$\text{EMF} = \frac{W}{q} \text{ or } \frac{[ML^2T^{-2}]}{[Q]} = [ML^2T^{-2}Q^{-1}]$$

or $$\text{EMF} = \frac{[ML^2T^{-2}]}{[AT]}$$

$$\text{EMF} = [ML^2T^{-3}A^{-1}]$$

318. Distance Z travelled by a particle is defined by $Z = \alpha + \beta t + \gamma t^2$. Dimensions of γ are

(a) $[LT^{-1}]$ (b) $[L^{-1}T]$
(c) $[LT^{-2}]$ (d) $[LT^2]$

SRMJEE - 2009

Ans. (c) : $Z = \alpha + \beta t + \gamma t^2$

$[Z] = [\alpha] = [\beta t] = [\gamma t^2]$

$\therefore$ $[Z] = [\gamma t^2]$

$[L] = [T^2]\ \gamma = [LT^{-2}]$

319. Given that force (F) is given by $F = Pt^{-1} + Qt$. Here t is time. The unit of P is same as that of

(a) Acceleration (b) Momentum
(c) Velocity (d) Displacement

SRMJEE - 2010

Ans. (b) : $F = Pt^{-1} + Qt$

$[F] = [Pt^{-1}] = [Qt]$

$\Rightarrow [P] = [F][t] = [MLT^{-2}][T]$

$= [MLT^{-1}] = [P]$

The units of P is same as that of momentum.

320. The velocity v of water may depend on their wavelength λ, density of water ρ and the acceleration due to gravity g. Which of the following relations is correct?

(a) $v^2 \propto \frac{\lambda}{g\rho}$ (b) $v^2 \propto g\lambda$

(c) $v^2 \propto \frac{g\rho}{\lambda}$ (d) $v^2 \propto \frac{g}{\lambda}$

SRMJEE - 2011

Ans. (b) : $v = k\lambda^a\rho^b g^c$ ....(i)

Here k is a dimensionless quantity.

$[LT^{-1}]=[L]^a[ML^{-3}]^b[LT^{-2}]^c$

$[M^0LT^{-1}] = [M^bL^{a-3b+c}T^{-2c}]$

On comparing the two sides we get

$b = 0$

$-2c = -1 \Rightarrow c = \frac{1}{2}$

$a - 3b + c = 1 \Rightarrow a - 3 \times 0 + \frac{1}{2} = 1 \Rightarrow a = \frac{1}{2}$

On putting value of a, b, c in equation (i), we get

$v = k\lambda^{1/2}\rho^0 g^{1/2}$

$v = (\lambda g)^{1/2}$

$v^2 \propto \lambda g$

321. Which of the following pairs DOES NOT have the same dimensions?

(a) frequency and angular frequency
(b) angular velocity and velocity gradient
(c) velocity gradient and angular frequency
(d) angular frequency and potential energy gradient

SRMJEE - 2012

Ans. (d) : Angular frequency $[\omega] = [T^{-1}]$

Potential energy gradient $\left[\frac{dV}{dx}\right] = \left[MLT^{-2}\right]$

Angular frequency and Potential energy gradient does not have the same dimensions.

322. Given that p = momentum, c = speed of light, then the dimensions of pc are same as that of :

(a) power (b) force
(c) angular momentum (d) torque

SRMJEE - 2013

Ans. (d) : New dimension $p \times c = [ML^{-1}T^{-2}]$

pc has the dimension $[ML^{-1}T^{-2}]$

Also Torque $\tau = F \times r$

$[\tau] = [ML^{-1}T^{-2}]$

$\therefore\ [pc] = [\tau]$

323. Dimensions are not same for the pair

(a) Torque and work
(b) Momentum and impulse
(c) Pressure and stress
(d) Power and strain

SRMJEE - 2014

Ans. (d) : $[P] = [ML^2T^{-3}]$

But strain is dimensionless.

324. If L, C, R denote the inductance, capacitance and resistance respectively, the dimensional formula for C^2LR is

(a) $M^0L^0T^3I^0$ (b) $ML^{-2}TI^0$
(c) $M^0L^0T^2I^0$ (d) $M^{-1}L^{-2}T^6I^2$

SRMJEE - 2014

Ans. (a) : $[L] = [ML^2T^{-2}I^{-2}]$

$[C] = [M^{-1}L^{-2}T^4I^2]$ $[R] = [ML^2T^{-3}I^{-2}]$

$\therefore\ [C^2LR]=[M^0L^0T^3I^0]$

325. Out of the following pairs, which one does not have the same dimensions?

(a) angular momentum and Planck's constant
(b) impulse and momentum
(c) moment of inertia and moment of force
(d) work and torque

SRMJEE - 2016

Ans. (c) : $[L] = [h] = [M^0LT^0]$

$[J] = [\Delta p] = MLT^{-1}]$

$[\omega] = [\tau] = [ML^2T^{-2}]$

$I = MR^2$ and momentum of force is torque.

$\Rightarrow [I] = [ML^2]$ and $\tau = F \times r$

$[\tau] = [ML^2T^{-2}]$

@apna_pdf

326. The dimension of the ratio of angular momentum of linear momentum is

(a) L^0 (b) L^1
(c) L^2 (d) MLT

SRMJEE - 2016

Ans. (b) : Angular momentum L = mvr
Linen momentum = p = mv

$$\frac{[L]}{[p]}=\frac{[ML^2T^{-1}]}{[MLT^{-1}]}=[M^0L^1T^0]$$

327. Select the pairs which have same dimensions :

(a) torque and work
(b) energy and Young's modulus
(c) work and pressure
(d) angular momentum and work

MP PET -2013

Ans. (a) : Torque and work have same dimension.

$$\text{Torque}=\text{Force}\times\text{Distance}$$
$$=\left[ML^2T^{-2}\right]$$
$$\text{Work}=\text{Force}\times\text{Displacement}$$
$$=\left[ML^2T^{-2}\right]$$

328. The dimensions of Reynold's number are

(a) $[M^0L^{-1}T^{-1}]$ (b) $[M^0L^0T^0]$
(c) $[M^1L^0T^{-2}]$ (d) $[M^1L^{-2}T^{-1}]$

Assam CEE-2021
BCECE-2009

Ans. (b) : ∵

$$\text{Reynolds Number }(R_e)=\frac{\text{Density}\times\text{Velocity}\times\text{length}}{\text{dynamic viscocity}}$$

$$[R_e]=\frac{[D]\times[V]\times[L]}{[\eta]}$$
$$=\frac{[ML^{-3}T^0]\times[M^0LT^{-1}]\times[L]}{[ML^{-1}T^{-1}]}$$
$$=[M^0L^0T^0]$$

329. Which of the following expressions has the same dimension as that of light-year? (In the following expressions, h is Planck's constant, c is the velocity of light and G denotes Newton's gravitational constant.)

(a) $\sqrt{\frac{Gh}{2\pi c^3}}$ (b) $\sqrt{\frac{ch}{2\pi G}}$
(c) $\sqrt{\frac{Gh}{2\pi c^5}}$ (d) None of these

Assam CEE-2016

Ans. (a) : Given that,
Speed of light = c
Planck's constant = h
Gravitational constant = G
Light year is unit of length

$$L\propto h^a c^b G^c$$
$$\left[M^0L^1T^0\right]=\left[ML^2T^{-1}\right]^a\left[LT^{-1}\right]^b\left[M^{-1}L^3T^{-2}\right]^c$$
$$\left[M^0L^1T^0\right]=\left[M^{a-c}L^{2a+b+3c}T^{-a-b-2c}\right]$$

On comparing,

$$a-c=0\Rightarrow a=c \quad \ldots(i)$$
$$2a+b+3c=1$$
$$2a+3a+b=1$$
$$5a+b=1 \quad \ldots(ii)$$

and

$$-a-b-2c=0$$
$$a+b+2c=0$$
$$b+3a=0$$
$$b=-3a \quad \ldots(iii)$$

From (ii) and (iii), we get

$$b=1-5a=-3a$$
$$1=2a$$
$$\Rightarrow a=\frac{1}{2}$$
$$\therefore a=\frac{1}{2},c=\frac{1}{2},b=\frac{-3}{2}$$
$$\therefore L\propto h^{\frac{1}{2}}G^{\frac{1}{2}}C^{\frac{-3}{2}}$$
$$\boxed{L\propto\sqrt{\frac{hG}{c^3}}}$$

330. The dimensions of $\varepsilon_0\frac{d\phi_E}{dt}$ are of

(a) potential (b) charge
(c) capacitance (d) current

Assam CEE-2014

Ans. (d) : Displacement current I_D is defined as

$$I_D=\frac{dQinside}{dt}=\varepsilon_0\frac{d\phi_e}{dt}$$

Hence, dimension of $\varepsilon_0\frac{d\phi_e}{dt}$ in equal to dimension of I (Current).

331. The amplitude of a damped oscillator of mass with time t as

$$\mathbf{A=A_0e^{-at/m}}$$

The dimensions of a are

(a) $[ML^0T^{-1}]$ (b) $[M^0LT^{-1}]$
(c) $[MLT^{-1}]$ (d) $[ML^{-1}T]$

Assam CEE-2014

Ans. (a) : Given that, Mass = m, Time = t

Amplitude of damped oscillator, $A=A_0e^{-\frac{at}{m}}$

because of the term $-\frac{at}{m}$ is the exponential term thus dimension of $-\frac{at}{m}$ is dimension less

i.e.1

$$\dim[-\frac{at}{m}]=1$$

@apna_pdf

$$[a]\times\frac{[t]}{[m]}=1$$

$$[a]\times\frac{[T]}{[M]}=1$$

$$[a]=[M^1T^{-1}]$$

$$[a]=[M^1L^0T^{-1}]=[ML^0T^{-1}]$$

332. If energy (E), velocity (V) and force (F) are considered to be fundamental units, then dimension of mass will be

(a) $[EV^{-2}]$ (b) $[FV^{-2}]$

(c) $[EF^{-2}]$ (d) $[FV^{-1}]$

Tripura-2020

Assam CEE-2014

Ans. (a) : $[E]=ML^2T^{-2}$

$$[V]=M^0L^1T^{-1}$$

$$[F]=M^1L^1T^{-2}$$

Let, dimension of mass in E is = x

dimension of mass in V is = y

dimension of mass in F is = z

Then, $M\propto E^xV^yF^z$

$$[M^1L^0T^0]=[ML^2T^{-2}]^x[M^0LT^{-1}]^y[M^1L^1T^{-2}]^z$$

$$[M^1L^0T^0]=[M^{x+z}L^{2x+y+z}T^{-2x-y-2z}]$$

$x+z=1$ ….. (i)

$2x+y+z=0$ ….. (ii)

$2x+y+2z=0$ ….. (iii)

On solving equation (i), (ii) and (iii), we get

$x=1, y=-2, z=0$

So,

$$[M]=[EV^{-2}]$$

333. The dimensional formula for the magnetic field is

(a) $[MT^{-2}A^{-1}]$ (b) $[ML^2T^{-1}A^{-2}]$

(c) $[MT^{-2}A^{-2}]$ (d) $[MT^{-1}A^{-2}]$

AMU-2010

Ans. (a) : since we know that magnetic force-

$F = qvB\sin\theta$ ……….(i)

Where B = magnetic field

∵ $\sin\theta$ is dimensionless

And dimension of F, V, q-

$F=[MLT^{-2}]$

$V=[LT^{-1}]$

$q=[AT]$

From equation (i)

$$B=\frac{F}{qv\sin\theta}$$

dimensional formula of B-

$$B=\frac{[MLT^{-2}]}{[AT][LT^{-1}]}$$

$$B=[M^1L^0T^{-2}A^{-1}]$$

334. A quantity X is given by $\varepsilon_0L\frac{\Delta V}{\Delta t}$, Where ε_0 is the permittivity of free space, L is a length, ΔV is a potential difference and Δt is time interval. The dimensional formula for X is the same as that of:

(a) electrical resistance (b) electric charge

(c) electric voltage (d) electric current

AMU-2009

Ans. (d) : given:-

$$X=\varepsilon_0L\frac{\Delta v}{\Delta t} \quad \text{………(1)}$$

We know that,

Capacitance, $C=\varepsilon_0L$ ……..(2)

∴ from equation (1) and (2)

$$X=\frac{C\Delta v}{\Delta t} \quad \text{…….(3)}$$

∵ Charge, $q = C\times V$ …….(4)

∴ From equation (3) and (4)

$$X=\frac{q}{\Delta t} \quad \text{……..(5)}$$

Now, since we know that charge, $q = it$

$$i=\frac{q}{t} \quad \text{……..(6)}$$

On comparing equation (5) and (6)

X = I (current)

Hence option (d) is correct

335. If E, m, I, and G denote energy, mass, angular momentum and gravitational constant respectively, the quantity (EI^2/m^5G^2) has the dimensions of

(a) angle (b) length

(c) mass (d) time.

AMU-2008

Ans. (a) : energy E, Angular momentum I, mass (m) Gravitational constant (G) dimensional formula of the above quantities

Energy (E) = $[ML^2T^{-2}]$

Mass (m) = $[M^1]$

Angular momentum (I) = $[ML^2T^{-1}]$

Gravitational constant (G) = $[M^{-1}L^3T^{-2}]$

Now: Dimensional formula of $\frac{EI^2}{m^5G^2}$

$$\Rightarrow\frac{EI^2}{m^5G^2}=\frac{[M^1L^2T^{-2}][M^1L^2T^{-1}]^2}{[m]^5[M^{-1}L^3T^{-2}]^2}$$

$$\Rightarrow\frac{EI^2}{m^5G^2}=\frac{[M^3L^6T^{-4}]}{[M^3L^6T^{-4}]}=[M^0L^0T^0]$$

∴ Dimensional formula of $\frac{EI^2}{m^5G^2}$ is $[M^0L^0T^0]$

∴ Dimensional formula of angle = $[M^0L^0T^0]$

So, option (a) is correct.

@apna_pdf

336. The dimension of magnetic field in M, L, T and C (coulomb) is given as

(a) $[MLT^{-1}C^{-1}]$ (b) $[MT^{-2}C^{-1}]$

(c) $[MT^{2}C^{-2}]$ (d) $[MT^{-1}C^{-1}]$

AMU-2015

Ans. (d) :

$F = Bqv\sin\theta$

Or $B = \dfrac{F}{qv\sin\theta}$

$\because$ sin θ is dimensionless

$\therefore$ dimensional formula of magnetic field , $B = \dfrac{F}{qv}$

$$= \frac{[MLT^{-2}]}{[C][LT^{-1}]}$$

$$[B] = \frac{[ML^0T^{-1}]}{[C]}$$

$$[B] = [ML^0T^{-1}C^{-1}]$$

Or $[B] = [MT^{-1}C^{-1}]$

Hence option (d) is correct.

337. What are the dimensions of $\dfrac{A}{B}$ in the relation, $F = A\sqrt{x} + Bt^2$, where F is the force, x is distance and t is time?

(a) $[ML^2T^{-2}]$ (b) $[L^{-1/2}T^2]$

(c) $[L^{-1/2}T^{-1}]$ (d) $[LT^{-2}]$

AMU-2014

Ans. (b) : Equation, $F = A\sqrt{x} + Bt^2$

By rule of dimension-

Dimension of F = Dimension of $A\sqrt{x}$

$$[MLT^{-2}] = A[L^{1/2}]$$

$$A = \frac{[MLT^{-2}]}{[L^{1/2}]}$$

$$A = [ML^{1/2}T^{-2}]$$

Dimension of F = Dimension of Bt^2

$$[MLT^{-2}] = [B][T^2]$$

$$[MLT^{-4}] = [B]$$

$$\therefore [B] = [MLT^{-4}]$$

According to question-

$$\left[\frac{A}{B}\right] = \frac{[ML^{1/2}T^{-2}]}{[ML^1T^{-4}]}$$

$$\left[\frac{A}{B}\right] = [M^0L^{-1/2}T^{-2}]$$

$$\left[\frac{A}{B}\right] = [L^{-1/2}T^2]$$

so, option (b) is correct

338. The dimensions of the quantity $\dfrac{L}{RCV}$ are those of

(a) Charge

(b) $(\text{Charge})^{-1}$

(c) Current

(d) $(\text{Current})^{-1}$

Here L, C r and V represent respectively the inductance, capacitance, resistance and potential difference.

AMU-2006

Ans. (d) : Given that,

Quantity $= \dfrac{L}{RCV}$

RC is the time constant (T) and it has unit of time.

We know that,

$V = IR$

$\dfrac{L}{R}$, CR and $\sqrt{LC}$ have same dimension of time.

$$\therefore \left[\frac{L}{R}\right] = [T]$$

also dimension of CV, $[CV]=[A][T]$

$$\therefore \frac{L}{RCV} = \frac{[T]}{[A][T]} = [A]^{-1}$$

$$= [A^{-1}] = [M^0L^0T^0A^{-1}]$$

Hence, option (d) is correct

339. The Hubble constant has the dimension of

(a) time (b) $(\text{time})^{-1}$

(c) length (d) mass

AMU-2001

Ans. (b) : Hubble constant is the value that show relation between the velocity of two galaxies and distance between them.

It is proportionality constant.

Hubble constant $= \dfrac{\text{Velocity}}{\text{Distance}}$

Unit of Hubble constant $= \left(\dfrac{m/sec}{m}\right)$

Unit of H.C = (second^{-1})

So, dimension of Hubble constant is time^{-1}.

$\therefore$ Dimension of Hubble constant = $[T^{-1}]$

340. In the following equation, x, t and f represent respectively, displacement, time and force:

$$F = a + bt + \frac{1}{c + d.x} + A\sin(\omega t + \varphi).$$

The dimensional formula for A.d is

(a) $[T^{-1}]$ (b) $[L^{-1}]$

(c) $[M^{-1}]$ (d) $[TL^{-1}]$

AMU-2011

@apna_pdf

Ans. (b) : $F = a + bt + \frac{1}{C + dx} + A\sin(\omega t + \phi)$

The rule of dimension-

From dimensional homogeneity should also be same unit as F.

Dimensional formula of (F) = $[MLT^{-2}]$

So, Dimensional of A = $[MLT^{-2}]$

Again from dimensional rule-

$$\frac{1}{C + d.x} = \left[MLT^{-2}\right]$$

$$\therefore C + d/x = \left[M^{-1}L^{-1}T^{2}\right]$$

$\because$ Both c and d.x have same dimensions

$$\therefore d.x = \left[M^{-1}L^{-1}T^{2}\right]$$

$$d\left[L\right] = \left[M^{-1}L^{-1}T^{2}\right]$$

$$d = \left[M^{-1}L^{-2}T^{+2}\right]$$

Now- $A.d = \left[MLT^{-2}\right]\left[M^{-1}L^{-2}T^{+2}\right]$

$$A.d = \left[M^{0}L^{-1}T^{0}\right]$$

$$A.d = [L^{-1}]$$

Hence, option (b) is correct.

341. If L, C and R denote the inductance, capacitance and resistance respectively, the dimensional formula for C^2LR is

(a) $[ML^{-2}T^{-1}I^{0}]$ (b) $[M^{0}L^{0}T^{3}I^{0}]$

(c) $[M^{-1}L^{-2}T^{6}I^{2}]$ (d) $[M^{0}L^{0}T^{2}I^{0}]$

Manipal UGET-2014

UP CPMT-2014

Ans. (b) : We know that,

Dimension of Inductance (L) = $[ML^{2}T^{-2}I^{-2}]$

Dimension of Capacitance [C] = $[M^{-1}L^{-2}T^{4}I^{2}]$

Dimension of Resistance (R) = $[ML^{2}T^{-3}I^{-2}]$

So,

The dimension formula of C^2LR is

$C^2LR = [M^{-1}L^{-2}T^{4}I^{2}]^2\,[ML^{2}T^{-2}I^{-2}]\,[ML^{2}T^{-3}I^{-2}]$

$= [M^{-2}L^{-4}T^{8}I^{4}]\,[M^{2}L^{4}T^{-5}I^{-4}]$

$= [M^{0}L^{0}T^{3}I^{0}]$

342. Position of a body with acceleration a is given by $x = ka^m t^n$, here t is time, find the dimension of m and n

(a) m = 1, n = 1 (b) m = 1, n = 2

(c) m = 2, n = 1 (d) m = 2, n = 2

Manipal UGET-2013

Ans. (b) : Given that,

$x = ka^m\,t^n$ $(\because k = \text{const.})$

Write dimensions in both side, we get–

$[M^{0}L^{1}T^{0}] = [LT^{-2}]^m\,[T]^n$

$[M^{0}L^{1}T^{0}] = [L^m\,T^{-2m+n}]$

Comparing the power on both sides, we get–

$m = 1$ and $-2m + n = 0$

$-2 \times 1 + n = 0$

$n = 2$

Hence, the dimension of m, n are 1 and 2 respectively.

343. In the equation

$$S_{nth} = u + \frac{a}{2}(2n - 1)$$

where, the letters have their usual meanings. The dimensions of S_{nth} are

(a) $\left[M^{0}L^{1}T^{-1}\right]$ (b) $\left[M^{0}L^{1}T^{0}\right]$

(c) $\left[M^{1}L^{0}T^{1}\right]$ (d) $\left[M^{1}L^{-1}T^{-1}\right]$

CG PET- 2015

Ans. (a) : The dimensional formula of S_{nth} is same as u (initial velocity)

$$S_{nth} = u + \frac{a}{2}(2n - 1)$$

$S_{nth} = u$

= m/sec.

$[S_{nth}] = [LT^{-1}]$

$[S_{nth}] = [M^{0}L^{1}T^{-1}]$

344. The dimension of pressure is

(a) $[ML^{2}T^{-2}]$ (b) $[MLT^{-2}]$

(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-2}T^{-2}]$

CG PET- 2012

Ans. (c) : We know that,

$$\text{Pressure (P)} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

Dimension of pressure,

$$P = \frac{\left[MLT^{-2}\right]}{\left[L^{2}\right]}$$

$$P = \left[ML^{-1}T^{-2}\right]$$

345. If in expression $X = 3YZ^2$, the dimension of X and Z are same as the dimensions of capacity and magnetic field respectively, the dimensional formula of Y is

(a) $\left[M^{-3}L^{-2}T^{-4}A^{-1}\right]$ (b) $\left[ML^{-2}T^{4}\right]$

(c) $\left[M^{-3}L^{-2}T^{4}A^{4}\right]$ (d) $\left[M^{-3}L^{-2}T^{8}A^{4}\right]$

BITSAT-2017, CG PET- 2011

Ans. (d) : Given the expression $X = 3YZ^2$

$$Y = \frac{X}{3Z^2}$$

Dimension of capacity $(X) = [M^{-1}L^{-2}T^{4}A^{2}]$

Dimension of magnetic field $(Z) = [MT^{-2}A^{-1}]$

$$\text{Dimension of } Y = \frac{[M^{-1}L^{-2}T^{4}A^{2}]}{[MT^{-2}A^{-1}]^2}$$

$$Y = \frac{[M^{-1}L^{-2}T^{4}A^{2}]}{[M^{2}T^{-4}A^{-2}]}$$

$$= \left[M^{-3}L^{-2}T^{8}A^{4}\right]$$

@apna_pdf

346. The velocity v (in cm/s) of a particle is given in terms of time t (in sec) by the relation $v = at + \frac{b}{t+c}$; the dimensions of a, b and c are

(a) a=$[L^2]$,b=$[T]$,c=$[LT^2]$
(b) a=$[LT^2]$,b=$[LT]$,c=$[L]$
(c) a=$[LT^{-2}]$,b=$[L]$,c=$[T]$
(d) a=$[L]$,b=$[LT]$,c=$[T^2]$

CG PET- 2007

Ans. (c) : $V = at + \frac{b}{t+c}\left[V = \text{velocity in cm/sec}\right]$

at must have dimension of V

Dimension of V = Dimension of at

$$at = V$$

$$a = \frac{\left[LT^{-1}\right]}{[T]}$$

Dimensional $a = \left[LT^{-2}\right]$

Dimension of $c = [t] = T$

Dimension of $\left[\frac{b}{t+c}\right] = [v]$

$$\left[\frac{b}{t+c}\right] = \left[LT^{-1}\right]$$

$$b = \left[LT^{-1}\right][T]$$

$$b = [L]$$

Hence, dimension of a, b, and c are

$$\left[LT^{-2}\right], [L] \text{ and } [T]$$

347. Which of the following can be written as kg-m^2 A^{-2} T^{-2}?

(a) Inductance
(b) Reactance
(c) Capacitance
(d) Resistance

CG PET- 2006

Ans. (a) : Inductance L is equal to the ratio of e.m.f. E to the rate of change of current w.r.to time.

$$L = \frac{E}{dI/dt}$$

Dimension of E is $[ML^2T^{-3}A^{-1}]$ and the dimension of $\frac{dI}{dt}$ is $[A^1T^{-1}]$

Therefore, the dimension of inductance

$$L = \frac{[ML^2T^{-3}A^{-1}]}{[AT^{-1}]}$$

$$L = [ML^2T^{-2}A^{-2}]$$

Then, unit of inductance $\Rightarrow$ kg $m^2T^{-2}A^{-2}$

348. $[ML^2T^{-3}]$ represents the dimensions of

(a) pressure
(b) energy
(c) power
(d) force

CG PET- 2005

Ans. (c) : Dimension of pressure $= \frac{\text{Force}}{\text{Area}}$

$$= \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

Dimension of energy = mc^2

= Mass × $(\text{velocity})^2$

= $[M]\,[LT^{-1}]^2 = [ML^2T^{-2}]$

Dimension of force, F = $[MLT^{-2}]$

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}} = \frac{F.s.}{t} = \frac{\left[MLT^{-2}\right]\times[L]}{[T]}$$

$$= \left[ML^2T^{-3}\right]$$

Hence, $\left[ML^2T^{-3}\right]$ is dimension of power.

349. The terminal velocity of a small ball falling in a viscous liquid depends upon (i) its mass m, (ii) its radius r, (iii) the coefficient of viscosity of the liquid η and (iv) acceleration due to gravity g. which of the following relations is dimensionally true for the terminal velocity? (where k is constant)

(a) v= k mg/ηr
(b) v= k mg r/η
(c) v= k mgη/r
(d) v= kηr/mg

CG PET- 2005

Ans. (a) : According to condition

Terminal velocity (v) is depend upon m,r,η and a

By choosing option (a)

$$v = k\,mg/\eta r$$

Given, k is constant,

mg has unit gm/s^2 and dimension $[M]\,[LT^{-2}]$

η viscosity has unit of kg/m-s and dimension $[ML^{-1}T^{-1}]$

r has unit of m and dimension $[L]$

and velocity 'v' has unit m/s and dimension $[LT^{-1}]$

$$\left[LT^{-1}\right] = \frac{[M]\times\left[LT^{-2}\right]}{\left[ML^{-1}T^{-1}\right]\times[L]}$$

$$\Rightarrow M^0L^1T^{-1}$$

$$\left[LT^{-1}\right] = \left[LT^{-1}\right]$$

Hence, option (a) has dimensionally true relation.

350. Which of the following group have different dimension?

(a) Potential difference, EMF, voltage
(b) Pressure, stress, Young's modulus
(c) Heat, energy, work done
(d) Dipole moment, electric flux, electric field

BITSAT-2005

Ans. (d) : Dipole moment $\left|\vec{P}\right| = 2lq$

Dimension of dipole = $[L^1T^1A^1]$

$$E = \frac{F}{q}$$

$$[E] = \frac{\left[MLT^{-2}\right]}{[AT]} = \left[MLT^{-3}A^{-1}\right]$$

@apna_pdf

Dimension of electric field = $[MLT^{-3}A^{-1}]$

Electric Flux $(\phi) = \vec{E}.\vec{A}$

$$= [MLT^{-3}A^{-1}][L^2]$$

$$= [ML^3T^{-3}A^{-1}]$$

Hence in option (d) dimension formulas are different.

351. The SI unit of the inductance, the henry cannot be written as

(a) weber/ampere (b) volt-second/ampere

(c) joule/(ampere)^2 (d) ohm-meter

BITSAT-2006

Ans. (d) : Inductance can be written as the ratio of magnetic flux to the current flowing i.e. $\frac{\text{Weber}}{\text{Ampere}}$

Unit of Weber is the product of volt and second. Hence unit of inductance can be written as $\frac{\text{Volt-second}}{\text{Ampere}}$

Energy (E) = VIt

Vt = E/I

Vt can be written as Joule / Ampere.

Inductance can also be written as $\frac{\text{Joule}}{(\text{Ampere})^2}$

And ohm-meter is unit of specific resistance.

So, the henry cannot be written as Ohm-meter

352. If P represents radiation pressure, C represents speed of light and Q represents radiation energy striking a unit area per second, the non-zero integers x, y and z such that $P^xQ^yC^z$ is dimensionless, are.

(a) $x = 1, y = 1, z = -1$ (b) $x = 1, y = 1, z = 1$

(c) $x = -1, y = 1, z = 1$ (d) $x = 1, y = 1, z = 1$

BITSAT-2010

Ans. (b) : $P^xQ^yC^z \rightarrow$ Dimensionless

$$[P^x][Q^y][C^z] = [M^0L^0T^0]$$

$$[P]^x[Q]^y[C]^z = [M^0L^0T^0] \qquad .....(i)$$

Dimension of pressure $= \frac{F}{A} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

Dimension of velocity $= \frac{\text{Distance}}{\text{Time}} = \frac{[L]}{[T]} = [LT^{-1}]$

Dimension of radiation energy striking per unit area per second $= \frac{\text{Jule}}{m^2\text{-sec}} = \frac{[ML^2T^{-2}]}{[L^2][T]} = [MT^{-3}]$

Then, putting these value in equation (i),

$[ML^{-1}T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z = [M^0L^0T^0]$

$[M^{x+y} L^{-x+z} T^{-2x-3y-z}] = [M^0L^0T^0]$

by comparing the power of M, L, T on both sides

$x + y = 0 \qquad .....(ii)$

$-x + z = 0 \qquad .....(iii)$

$-2x - 3y - z = 0 \qquad .....(iv)$

The only possible value in option (b) which satisfy above all three equations.

353. Wave pulse can travel along a tense string like a violin spring. A series of experiments showed that the wave velocity V of a pulse depends on the following quantities, the tension T of the string, the cross-section area A of the string and then as per unit volume ρ of the string. Obtain an expression for V in terms of the T, A and ρ using dimensional analysis.

(a) $V = k\sqrt{\frac{T}{A\rho}}$ (b) $V = k\sqrt{\frac{T}{A}}$

(c) $V = k\sqrt{\frac{A\rho}{T}}$ (d) None of these

BITSAT-2013

Ans. (a) : Equating the V as

$$V = kT^aA^b\rho^c \qquad .....(i)$$

Where, k is constant

Dimension of V = $[LT^{-1}]$

Dimension of T (Tension) = $[MLT^{-2}]$

Dimension of A = $[L^2]$

Dimension of ρ = $[ML^{-3}]$

Putting these in equation (i)

$[M^0LT^{-1}] = [MLT^{-2}]^a [L^2]^b [ML^{-3}]^c$

$[M^0L^1T^{-1}] = [M^{a+c} L^{a+2b-3c} T^{-2a}]$

Comparing both side power

$$a + c = 0$$

$$a + 2b - 3c = 1$$

$$-2a = -1$$

$$a = \frac{1}{2}$$

$$c = -\frac{1}{2}$$

$$b = \frac{-1}{2}$$

Putting these value in equation (i)

$$V = kT^aA^b\rho^c$$

$$V = k(T)^{1/2} A^{(-1/2)}\rho^{(-1/2)}$$

$$V = k\sqrt{\frac{T}{A\rho}}$$

354. If L, C and R are the inductance, capacitance and resistance respectively, then which of the following does not represent the dimension of frequency?

(a) $\left[\frac{R}{L}\right]$ (b) $\left[\frac{C}{L}\right]$

(c) $\left[\frac{1}{\sqrt{LC}}\right]$ (d) $\left[\frac{1}{RC}\right]$

JCECE-2016, UPSEE - 2015

@apna_pdf

Ans. (b) :

Dimension of resistance $[R]=\left[ML^2T^{-3}A^{-2}\right]$

Dimension of capacitance $[C]=\left[M^{-1}L^{-2}T^4A^2\right]$

Dimension of Inductance $[L]=\left[ML^2T^{-2}A^{-2}\right]$

$$\text{Dimension of } \frac{R}{L}=\frac{\left[ML^2T^{-3}A^{-2}\right]}{\left[ML^2T^{-2}A^{-2}\right]}$$

$$=\left[M^0L^0T^{-1}A^0\right] \quad =\left[T^{-1}\right]$$

$$\text{Dimension of } \frac{[C]}{[L]}=\frac{\left[M^{-1}L^{-2}T^4A^2\right]}{\left[ML^2T^{-2}A^{-2}\right]}=\left[M^{-2}L^{-4}T^6A^4\right]$$

This is not Dimension of frequency.

355. The air bubble formed by explosion inside water performed oscillation with time period T that is directly proportional to $p^ad^bE^c$, where p is the pressure, d is the density and E is the energy due to explosion. The values of a, b and c will be

(a) –5/6, 1/2, 1/3
(b) 5/6, 1/3, 1/2
(c) 5/6, 1/2, 1/3
(d) None of the above

UPSEE - 2008

Ans. (a) : Given that, time period $(T) \propto p^ad^bE^c$..........(i)

The dimensions of these quantities are given as

$$P=\left[ML^{-1}T^{-2}\right], \quad d=\left[ML^{-3}\right]$$

$$E=\left[ML^2T^{-2}\right]$$

On writing the dimension on both sides in equation (i)

$[M^0L^0T] \propto [ML^{-1}T^{-2}]^a\,[ML^{-3}]^b\,[ML^2T^{-2}]^c$

$[M^0L^0T] \propto [M^{a+b+c}\,L^{-a-3b+2c}\,T^{-2a-2c}]$

Now, comparing the powers of M, L, T on both sides–

$a+b+c=0$ .....(ii)

$-a-3b+2c=0$ .....(iii)

$-2a-2c=1$ .....(iv)

On solving above equations, we get value of a, b, c are $-\frac{5}{6},\frac{1}{2}$ and $\frac{1}{3}$ respectively.

356. In the relation x = cos (ωt + kx), the dimensions of ω are

(a) $\left[M^0LT\right]$
(b) $\left[M^0L^{-1}T^0\right]$
(c) $\left[M^0L^0T^{-1}\right]$
(d) $\left[M^0LT^{-1}\right]$

UPSEE - 2008

Ans. (c) : $x=\cos(wt+kx)$

Since, $\omega t+kx$ is dimensionless$\left[M^0L^0T^0\right]$

Therefore, $\omega t=\left[M^oL^oT^o\right]$

$$\omega=\frac{\left[M^oL^oT^o\right]}{[T]}$$

Dimension of$(\omega)=\left[M^oL^oT^{-1}\right]$

357. The dimensions of electric dipole moment are

(a) $[L^2A]$
(b) $[LA]$
(c) $[LTA]$
(d) $[T^{-2}]$

UPSEE - 2008

Ans. (c): We know, dipole moment = charge × distance

Where, $Q=i.t$

Charge = current × time

∴ Dipole moment = current × time × distance

Hence, dimension of dipole moment $=[ATL]$

358. Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be

(a) $[ML^2T^{-3}I^{-1}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^2T^{-1}I^{-1}]$
(d) $[ML^2T^{-3}I^{-2}]$

JCECE-2008

UPSEE - 2007

Ans. (d) : $V=iR$

$$\text{Resistance } =\frac{\text{volt}}{\text{current}}$$

Electric potential = Work done per unit charge

$$R=\frac{W}{qi} \qquad \left[\because V=\frac{W}{q}\right]$$

$$R=\frac{W}{i^2t} \qquad [\because q=it]$$

$$R=\frac{\left[ML^2T^{-2}\right]}{\left[I^2T\right]}$$

Dimension of $[R]=\left[ML^2T^{-3}I^{-2}\right]$

359. What is dimensional formula of thermal conductivity?

(a) $[MLT^{-1}\theta^{-1}]$
(b) $[MLT^{-3}\theta^{-1}]$
(c) $[MLT^{-3}\theta^{-2}]$
(d) $[ML^2T^{-2}\theta]$

UPSEE - 2006

Ans.(b) :

$$\text{We know that, } k=\frac{q\times d}{A(T_1-T_2)t}$$

Where, t = time

A = Area

d = Distance

Dimension of heat $(q)=\left[ML^2T^{-2}\right]$

$$[k]=\frac{\left[ML^2T^{-2}\right]\times[L]}{\left[L^2\right]\left[\theta^{+1}\right][T]}$$

Dimension of thermal conductivity $(k)=\left[MLT^{-3}\theta^{-1}\right]$

360. 1 Wb/m^2 is equal to :

(a) 10^4 gauss
(b) $4\pi \times 10^{-3}$ gauss
(c) 10^2 gauss
(d) 10^{-4} gauss

UPSEE - 2005

@apna_pdf

Ans. (a) : $1\text{ Tesla} = 1\text{NC}^{-1}\text{M}^{-1}\text{S} = 1\text{ Wbm}^{-2}$

In CGS system,

$$1\text{ tesla} = 10^4\text{gauss} = 1\text{wb}/\text{m}^2$$

361. The dimensions of $e^2/4\pi\varepsilon_0hc$, where e, ε_0, h and c are electronic charge, electric permittivity, Planck's constant and velocity of light in vacuum respectively, is :

(a) $[M^0L^0T^0]$ (b) $[M^1L^0T^0]$
(c) $[M^0L^1T^0]$ (d) $[M^0L^0T^1]$

UPSEE - 2004

Ans. (b) : Let, $x = \dfrac{e^2}{4\pi\varepsilon_o hc}$ ....(1)

Dimension of charge (e) = [AT]

Dimension of electric permittivity $(\varepsilon_o) = \left[M^{-1}L^{-3}T^4A^2\right]$

Dimension of Planck's constant $(h) = \left[ML^2T^{-1}\right]$

Dimension of speed of light $(c) = \left[LT^{-1}\right]$

Putting all dimension in equation (i), we get –

$$[x] = \frac{[AT]^2}{\left[M^{-1}L^{-3}T^4A^2\right]\left[ML^2T^{-1}\right]\left[LT^{-1}\right]}$$

$$[x] = \left[M^oL^oT^o\right]$$

362. The physical quantity that does not have the dimensional formula $[ML^{-1}T^{-2}]$ is

(a) force (b) pressure
(c) stress (d) modulus of elasticity
(e) energy density

Kerala CEE - 2015

Ans. (a): We know that,

Force, F = ma

Dimension of force (F) = $[M]\,[LT^{-2}] = [MLT^{-2}]$

Dimension of stress = $[ML^{-1}T^{-2}]$

Dimension of modulus of elasticity = $[ML^{-1}T^{-2}]$

Dimension of pressure = $[ML^{-1}T^{-2}]$

Dimension of energy density = $[ML^{-1}T^{-2}]$

Hence, force does not have the dimensional formula $[ML^{-1}\,T^{-2}]$

363. The quantity which has the same dimensions as that of gravitational potential is

(a) latent heat
(b) impulse
(c) angular acceleration
(d) Planck's constant
(e) specific heat capacity

Kerala CEE- 2013

Ans. (a) : Gravitational potential $(v) = \dfrac{\text{Work}}{\text{Mass}}$

$$= \frac{\left[ML^2T^{-2}\right]}{[M]}$$

$$= \left[L^2T^{-2}\right]$$

Dimension of Latent Heat

$$(L) = \frac{Q}{M} = \frac{\left[ML^2T^{-2}\right]}{[M]}$$

$$(L) = \left[L^2T^{-2}\right]$$

Dimension of Impulse (P) $= mv = \left[MLT^{-1}\right]$

Dimension of Angular acceleration $(\alpha) = \left[T^{-2}\right]$

Dimension of Specific Heat,

$$(s) = \frac{Q}{m\Delta t}$$

$$(s) = \left[M^oL^2T^{-2}K^{-1}\right]$$

Dimension Planck constant $(h) = \dfrac{E}{v} = \left[ML^2T^{-1}\right]$

Where, E = energy, h = Planck's constant

v = frequency

Hence, Latent Heat dimension same as of gravitational potential.

364. The displacement of a particle moving along x-axis with respect to time t is $x = at + bt^2 - ct^3$. The dimensions of c are

(a) $[T^{-3}]$ (b) $[LT^{-2}]$
(c) $[LT^{-3}]$ (d) $[LT^3]$
(e) $[LT^2]$

Kerala CEE 2012

Ans. (c) : Given,

$x = at + bt^2 - ct^3$
x = displacement
t = time

Checking the dimensional consistency of equations.

Dimension of x = Dimension of ct^3

$$[c] = \frac{x}{t^3} = [LT^{-3}]$$

365. If C is the capacitance and V is the potential, the dimensional formula for CV^2 is

(a) $[ML^2T^{-1}]$ (b) $[ML^{-2}T^{-3}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-2}T^{-2}]$
(e) $[ML^{-1}T^{-1}]$

Kerala CEE – 2008
Karnataka CET - 2011

Ans. (c) : Let dimension formula of $CV^2 = x$

$$x = CV^2$$

$$\begin{bmatrix} C = \text{capacitance} \\ V = \text{Potential} \end{bmatrix}$$

We know that,

$$C = \frac{Q}{V}$$

Work done $W = V.Q \Rightarrow V = \dfrac{W}{Q}$

So, $C = \dfrac{Q^2}{W} = \dfrac{(It)^2}{W}$

@apna_pdf

$$[C]=\frac{[A^2T^2]}{[ML^2T^{-2}]}=\frac{[A^2T^4]}{[ML^2]}$$

$$[C]=[M^{-1}L^{-2}A^2T^4]$$

Now,

$$V=\frac{W}{Q}=\frac{[ML^2T^{-2}]}{[AT]}$$

$$[V]=[ML^2T^{-3}A^{-1}]$$

$[x] = [M^{-1}L^{-2}T^4A^2]\ [ML^2T^{-3}A^{-1}]^2$

$[x] = [ML^2T^{-2}]$

366. Which of the following sets of quantities have same dimensional formula ?

(a) Frequency, angular frequency and angular momentum

(b) Surface tension, stress and spring constant

(c) Acceleration, momentum and retardation

(d) Thermal capacity, specific heat and entropy

(e) Work, energy and torque

Kerala CEE 2006

Ans. (e) : Work, energy and torque have same dimensional formula

Work = Energy = Torque = $[ML^2T^{-2}]$

367. The dimensions of kinetic energy is:

(a) $[M^2L^2T^1]$ (b) $[M^1L^2T^1]$

(c) $[M^1L^2T^{-2}]$ (d) $[M^1L^2T^{-1}]$

(e) $[M^2L^2T^{-2}]$

Kerala CEE 2004

Ans. (c) : Kinetic Energy (K) $=\frac{1}{2}mv^2$

$[K] = [M]\ [LT^{-1}]^2$

$[K] = [M^1L^2T^{-2}]$

368. The potential energy of a particle varies with height h form a fixed point as $E=\left(\frac{P\sqrt{h}}{h+Q}\right)$ where, P and Q are constants. The dimensions of P Q are

(a) $[ML^2\ T^{-2}]$ (b) $[M^{3/2}\ L^{3/2}T^{-2}]$

(c) $[ML^{7/2}T^{-2}]$ (d) $[ML^{3/2}T^{-2}]$

JCECE-2015

Ans. (c) : Given,

$$E=\frac{P\sqrt{h}}{h+Q}\ \text{……..(i)}$$

Dimension of energy (E) = $[M\ L^2\ T^{-2}]$ ……….(2)

By the principle of dimensional homogeneous.

Dimension of Q = $[L^1]$= Dimension of h ……….(3)

Putting value of eq^n (2) and (3) in eq^n (1), we get

$$\left[ML^2T^{-2}\right]=\frac{P[L]^{1/2}}{[L]}$$

$$P=\frac{\left[ML^2T^{-2}\right]\left[L^1\right]}{[L]^{1/2}}$$

$P = [ML^{5/2}\ T^{-2}]$

$\therefore$ Dimension of (P × Q) = $[ML^{5/2}\ T^{-2}][L^1]$

$= [ML^{7/2}\ T^{-2}]$

369. The frequency of vibration of string is given by

$$v=\frac{\mathbf{p}}{\mathbf{2l}}\left[\frac{\mathbf{F}}{\mathbf{m}}\right]^{1/2}$$

Here, p is the number of segments in the string and *l* is the length. The dimensional formula for m will be

(a) $[M^0LT^{-1}]$ (b) $[ML^0T^{-1}]$

(c) $[ML^{-1}T^0]$ (d) $[M^0L^0T^0]$

JCECE-2014

BITSAT-2016

Ans. (c) : Given,

$$v=\frac{p}{2l}\left[\frac{F}{m}\right]^{1/2}$$

$$m^{1/2}=\frac{p}{2lv}(F)^{1/2}$$

Squaring on both side

$$\left(m^{1/2}\right)^2=\left(\frac{p}{2lv}\right)^2\left[(F)^{1/2}\right]^2$$

$$m=\frac{p^2}{4l^2v^2}[F]$$

$$\text{Dimension of } m=\frac{\left[MLT^{-2}\right]}{[L]^2\left[T^{-1}\right]^2}=\left[ML^{-1}T^0\right]$$

370. The dimensions of angular momentum/ magnetic moment are

(a) $[MA^{-1}T^{-1}]$ (b) $[M^{-1}AT^{-1}]$

(c) $[MAT^{-1}]$ (d) $[MA^{-1}T]$

JCECE-2013

Ans. (a) : Dimension of angular momentum

$= [ML^2T^{-1}]$

Magnetic moment = Current × Area

Dimension of magnetic moment = $[AL^2]$

$$\text{Now,}\quad\frac{\text{Dimension of angular momentum}}{\text{Dimension of magnetic moment}}$$

$$=\frac{[ML^2T^{-1}]}{[AL^2]}=[MA^{-1}T^{-1}]$$

371. The three physical quantities x, y and z have units g cm^2s^{-5}, g s^{-1} and cms $^{-2}$ respectively. The relation between x, y and z is

(a) $x = yz^2$ (b) $x = y^2\ z$

(c) $y^2 = xz$ (d) $z = x^2\ y$

JCECE-2012

Ans. (a) : Given,

Unit of x = g. $cm^2.s^{-5}$ ...(i)

Unit of y = g . s^{-1} ...(ii)

Unit of z = cm.s^{-2} ...(iii)

Then,

Unit of x = g. $cm^2.s^{-5}$

$= (g.s^{-1})\ (cm.s^{-2})^2$

= unit of y . unit of z^2 [from (ii) & (iii)]

So, the relation is $x = yz^2$

@apna_pdf

372. The magnetic moment has dimensions of

(a) [LA] (b) $[L^2 A]$

(c) $[LT^{-1} A]$ (d) $[L^2 T^{-1}A]$

JCECE-2007

AIIMS-2006

Ans. (b) : Magnetic moment of a current carrying coil is defined as the product of current in the coil with the area of coil in vector form. That is,

$$\vec{M} = I\vec{A}$$

Thus, dimensions of M = [A] $[L]^2$

$= [L^2 A]$

373. If the velocity of light c, gravitational constant G and Planck's constant h, are chosen as fundamental units, the dimensional formula of length L in the new system is:

(a) $[h^1c^1G^{-1}]$ (b) $[h^{1/2}c^{1/2}G^{-1/2}]$

(c) $[h^1c^{-3}G^1]$ (d) $[h^{1/2}c^{-3/2}G^{1/2}]$

JCECE-2005

Ans. (d) : Every equation relating physical quantities should be the dimensional balance.

In order to establish relation among various physical quantities, let a, b, c be the powers to which h, c and G are raised, then

$[M^0L^1T^0] = [h^ac^bG^c]$

Putting the dimensions on RHS of above equation, we get

$$\left[M^0L^1T^0\right]=\left[ML^2T^{-1}\right]^a\left[LT^{-1}\right]^b\left[M^{-1}L^3T^{-2}\right]^c$$

$$\left[M^0L^1T^0\right]=\left[M^{a-c}L^{2a+b+3c}T^{-a-b-2c}\right]$$

Comparing the power, we get

$a-c = 0$ …(i)

$2a + b + 3c = 1$ …(ii)

$-a-b-2c = 0$ …(iii)

Solving Equation. (i), (ii) and (iii), we get

$$a=\frac{1}{2}, b=\frac{-3}{2}, c=\frac{1}{2}$$

Hence, $[L] = [h^{1/2}\,c^{-3/2}G^{1/2}]$

374. Dimensions of torque are :

(a) $[M^2L^2T^{-2}]$ (b) $[ML^2T^{-2}]$

(c) $[ML^2T^{-1}]$ (d) $[ML^0T^{-2}]$

JCECE-2003

AIIMS-2011

Ans. (b) :

Torque = moment of inertia × Angular acceleration

$\tau = I.\alpha$ kg m^2 × rad/s^2

Dimension of torque = $[M^1L^2T^0]\times[M^0L^0T^{-2}]$

$= [ML^2\,T^{-2}]$

Therefore, the torque is dimensionally represented as $[ML^2T^{-2}]$

375. Select the dimensional formula of $B^2/2\mu_0$.

(a) $[M^1L^1T^2]$ (b) $[M^{-1}L^1T^2]$

(c) $[M^{-1}L^{-1}T^{-2}]$ (d) $[M^1L^{-1}T^{-2}]$

GUJCET 2017

Ans. (d) : Energy density $(\rho)=\dfrac{[\text{Energy}]}{[\text{Volume}]}=\dfrac{B^2}{2\mu_0}$

Energy density $=\dfrac{[\text{Force}]\times[d]}{[\text{Volume}]}$

$$=\frac{\left[MLT^{-2}\right]\times[L]}{\left[L^3\right]}$$

$$=\frac{[ML^2T^{-2}]}{[L^3]}$$

$$=\left[ML^{-1}T^{-2}\right]$$

Therefore, the dimension of $\dfrac{B^2}{2\mu_0}$ is $[ML^{-1}\,T^{-2}]$

376. Match the following two columns.

Column 1	Column 2
(a) Electrical resistance	(p) $ML^3T^{-3}A^{-2}$
(b) Electrical potential	(q) $ML^2T^{-3}A^{-2}$
(c) Specific resistance	(r) $ML^2T^{-3}A^{-1}$
(d) Specific conducatnce	(s) None of these

(a) a-q, b-s, c-r, d-p (b) a-q, b-r, c-p, d-s

(c) a-p, b-q, c-s, d-r (d) a-p, b-r, c-q, d-s

GUJCET 2015

Ans. (b) : Column 1 **Column 2**

(a) Electric resistance → (q) $[ML^2\,T^{-3}A^{-2}]$

(b) Electric potential → (r) $[ML^2\,T^{-3}A^{-1}]$

(c) Specific resistance → (p) $[ML^3\,T^{-3}A^{-2}]$

(d) Specific conductance → (s) None of these

Voltage,

$$(V)=\frac{\text{work done}(w)}{\text{charge }(q)}=\frac{[ML^2T^{-2}]}{[AT]}=[ML^2T^{-3}A^{-1}]$$

Electric potential $(V)=\left[ML^2T^{-3}A^{-1}\right]$

Resistance $(R)=\dfrac{V}{I}=\dfrac{[ML^2T^{-3}A^{-1}]}{[A]}=[ML^2T^{-3}A^{-2}]$

$$R=\frac{\rho L}{A}$$

$$\Rightarrow \rho=\frac{RA}{L}=\frac{[ML^2T^{-3}A^{-2}][L^2]}{[L]}=[ML^3T^{-3}A^{-2}]$$

Specific resistance $(\rho)=[ML^3T^{-3}A^{-2}]$

Specific conductance (k) $=\dfrac{1}{\rho}=\dfrac{1}{[ML^3T^{-3}A^{-2}]}$

$= [M^{-1}L^{-3}T^3A^2]$

377. Dimensional formula for electric field is

(a) $[M^1L^2T^{-3}A^{-2}]$ (b) $[M^1L^2T^{-3}A^{-1}]$

(c) $[M^1L^1T^{-3}A^{-1}]$ (d) $[M^0L^0T^0A^0]$

GUJCET 2014

@apna_pdf

Ans. (c) : Electric field $(\mathrm{E}) = \dfrac{\text{Force}(\mathrm{F})}{\text{charge }(\mathrm{q})}$

Dimension of $\mathrm{E} = \dfrac{[\mathrm{MLT^{-2}}]}{[\mathrm{AT}]}$

$= [\mathrm{M^1L^1A^{-1}T^{-3}}]$

378. Which two of the following quantities are dimensionally equivalent?

(i) Force **(ii) Pressure**

(iii) Young's Modulus **(iv) Energy**

(a) (i) and (ii)
(b) (i) and (iii)
(c) (ii) and (iii)
(d) (ii) and (iv)

COMEDK 2014

Ans. (c): (i) Force = mass × acceleration

$= [\mathrm{M}]\,[\mathrm{LT^{-2}}]$

$= [\mathrm{MLT^{-2}}]$

(ii) Pressure $= \dfrac{\mathrm{F}}{\mathrm{A}}$

$= \dfrac{[\mathrm{MLT^{-2}}]}{[\mathrm{L^2}]} = [\mathrm{ML^{-1}T^{-2}}]$

(iii) Young' modulus $= \dfrac{\text{Longitudinal stress}}{\text{Longitudinal strain}}$

$= \dfrac{[\mathrm{ML^{-1}T^{-2}}]}{[\mathrm{M^0L^0T^0}]} = [\mathrm{ML^{-1}T^{-2}}]$

(iv) Energy = force × displacement

$= [\mathrm{M^1\,L^2\,T^{-2}}]$

From above solution, pressure and young modulus are dimensionally equivalent

379. The pair of quantities having same dimensions is

(a) impulse and surface tension
(b) angular momentum and work
(c) work and torque
(d) Young's modulus and energy

COMEDK 2013

Ans. (c) :

- Impulse = Force × time

$= [\mathrm{MLT^{-2}}][\mathrm{T}] = [\mathrm{MLT^{-1}}]$

- Surface tension $= \dfrac{\text{Force}}{\text{length}}$

$= \dfrac{[\mathrm{MLT^{-2}}]}{[\mathrm{L}]} = [\mathrm{ML^0T^{-2}}]$

- Angular momentum

= Moment of inertia × angular velocity

$= [\mathrm{ML^2}][\mathrm{T^{-1}}] = [\mathrm{ML^2T^{-1}}]$

- Work= Force × distance

$= [\mathrm{MLT^{-2}}][\mathrm{L}] = [\mathrm{ML^2T^{-2}}]$

- Energy$= [\mathrm{ML^2T^{-2}}]$

- Torque = Force × distance

$= [\mathrm{MLT^{-2}}][\mathrm{L}] = [\mathrm{ML^2T^{-2}}]$

- Young's modulus

$= \dfrac{\text{Force/Area}}{\text{Change in length/orignal length}}$

$= \dfrac{[\mathrm{MLT^{-2}}]/[\mathrm{L^2}]}{[\mathrm{L}]/[\mathrm{L}]} = [\mathrm{ML^{-1}T^{-2}}]$

So, from the given pair of physical quantities work and torque have the same dimensions $[\mathrm{ML^2T^{-2}}]$.

380. If $x = at + bt^2$ where x is measured in m and *t* in s, then the dimension of (b/a) is

(a) $[\mathrm{LT^2}]$
(b) $[\mathrm{LT^{-1}}]$
(c) $[\mathrm{T}]$
(d) $[\mathrm{T^{-1}}]$

COMEDK 2012

Ans. (d): Given,

$x = at + bt^2$

Dimensionally x, at and bt^2 are same

$[x] = [at] = [bt^2]$

$\left[\dfrac{b}{a}\right] = \left[\dfrac{t}{t^2}\right] = \left[\dfrac{1}{t}\right]$

$\dfrac{b}{a} = \dfrac{1}{[\mathrm{T}]} = [\mathrm{T^{-1}}]$

Hence, the dimension of $\dfrac{b}{a}$ is $[\mathrm{T^{-1}}]$

381. Assertion: Specific gravity of a fluid is a dimensionless quantity.

Reason: It is the ratio of density of fluid to the density of water.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2005

Ans. (a) : Specific gravity of fluid,

$(\mathrm{G}) = \dfrac{\text{Density of fluid}}{\text{Density of water at } 4^\circ\mathrm{C}}$

It is clear that the specific gravity of fluid is dimensionless quantity.

382. Assertion: The dimensional formula for relative velocity is same as that of the change in velocity.

Reason: Relative velocity of P w.r.t. Q is the ratio of velocity of P and that of Q.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

@apna_pdf

(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2002

Ans. (c) : The relative velocity is defined as the velocity of an object with respect to another object or observer. It is vector subtraction of two velocities.

Relative velocity of P w.r.t Q

$$V_r = V_P - V_Q$$

So, the dimensional formula of relative velocity is same as that of the change in velocity.

383. The dimensional formula of Farad is

(a) $[M^{-1}L^{-2}TQ]$ (b) $[M^{-1}L^{-2}T^2Q^2]$
(c) $[M^{-1}L^{-2}TQ^2]$ (d) $[M^{-1}L^{-2}T^2Q]$

AIIMS-2012

Ans. (b) : Dimension of Farad

$$\therefore \quad C = \frac{Q}{V}$$

As we know,

$$W = Q.V \quad \Rightarrow V = \frac{W}{Q}$$

$$C = \frac{Q^2}{W} \quad [\because Q = CV]$$

And $W = F.d$

Thus, $C = \dfrac{Q^2}{F.d}$

$$\text{Dimension of } C = \frac{[\text{Dimension of Q}]^2}{\text{Dimension of F} \times \text{dimension of d}}$$

$$= \frac{[Q^2]}{[M^1L^1T^{-2}].[L^1]}$$

$$= [M^{-1}L^{-2}T^2Q^2]$$

384. Which of the following pair of quantities do not have the same dimensions:

(a) Potential gradient, electric field
(b) Torque, kinetic energy
(c) Light year, time period
(d) Impedance, reactance

AIIMS-2011

Ans. (c) : Light year is unit of distance.

So, dimension of light year = [L]

- Time taken for one complete oscillation to occur is called time period.

So, Dimension of time period = [T]

385. Which of the following physical quantities do not have same dimensions?

(a) pressure and stress
(b) tension and surface tension
(c) strain and angle
(d) energy and work

AIIMS-2007, 2001

Ans. (b) : Tension is a force experienced within a body to resist another force applied externally.

Dimension of tension = Dimension of force

$$= [MLT^{-2}]$$

Surface tension is the force per unit length perpendicular to line drawn in the surface of the liquid.

Dimension of surface tension,

$$= \frac{\text{Force}}{\text{Length}} = \frac{[MLT^{-2}]}{[L]} = [MT^{-2}]$$

Dimension of surface tension = $[MT^{-2}]$

386. Velocity of light is equal to

(a) $\sqrt{\dfrac{1}{\varepsilon_0\mu_0}}$ (b) $\sqrt{\varepsilon_0/\mu_0}$
(c) ε_0/μ_0 (d) $\varepsilon_0\mu$

AIIMS-2002

Ans. (a) : Permeability $\mu_0 = 4\pi \times 10^{-7}$ N/A^2

Permitivity in vacuum $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2

Speed of light (vacuum)–

So, $$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \quad .....(i)$$

Putting value of μ_0 and ε_0 in equation (i)

$$= \frac{1}{\sqrt{4\pi \times 10^{-7} \times 8.85 \times 10^{-12}}}$$

$$= 3 \times 10^8 \text{ m/s}$$

Hence, velocity of light is equal to the value of $= \dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$

$$\text{Velocity of light (c)} = \sqrt{\frac{1}{\varepsilon_o\mu_o}}$$

387. The dimensional formula of wave number is–

(a) $[M^0L^0T^0]$ (b) $[M^0L^{-1}T^0]$
(c) $[M^0L^0T^{-1}]$ (d) $[M^{-1}L^{-1}T^0]$

BCECE-2012

Ans. (b) : Angular wave number (K)= $\dfrac{1}{\lambda}$

So, Dimension = 1/[L] = $[L^{-1}]$

$\therefore$ Dimension of wave number = $[M^0L^{-1}T^0]$

388. Which of the following pairs have identical dimensions?

(a) Momentum and force
(b) Pressure and surface tension
(c) Moment of force and angular momentum
(d) Surface tension and surface energy

BCECE-2011

@apna_pdf

Ans. (d) : As we know,

$$\text{Surface tension} = \frac{\text{Force}}{\text{length}}$$

$$= \frac{[MLT^{-2}]}{[L]}$$

$$= [MT^{-2}]$$

$$\text{Surface energy} = \frac{\text{work done}}{\text{increase in area}}$$

$$= \frac{\text{Force} \times \text{Length}}{(\text{Length})^2} = \frac{[MLT^{-2}][L]}{[L^2]}$$

$$= \frac{[ML^2T^{-2}]}{[L^2]} = [MT^{-2}]$$

Hence, surface tension and surface energy have identical dimensions.

389. If E = energy, G = gravitational constant, I = impulse and M = mass, then dimensions of $\frac{GIM^2}{E^2}$ are same as that of–

(a) time (b) mass
(c) length (d) force

BCECE-2008

Ans. (a) : Dimension of E = $[ML^2T^{-2}]$

$$\text{Dimension of G} = \left[\frac{Fd^2}{m_1m_2}\right]$$

$$= [M^{-1}L^3T^{-2}]$$

Dimension of I = [Force × time]

$$= [MLT^{-1}]$$

and Dimension of M = [M]

$$\therefore \text{ Dimension of } \frac{GIM^2}{E^2}$$

$$= \frac{[M^{-1}L^3T^{-2}][MLT^{-1}][M^2]}{[ML^2T^{-2}]^2}$$

= [T]

Hence, dimension of $\frac{GIM^2}{E^2}$ will be same as time.

390. A gas bubble formed from an explosion under water oscillates with a period T proportional to $P^ad^bE^c$, where P is pressure, d is the density of water and E is the total energy of explosion. The value of a,b,c, are–

(a) a = 1, b = 1, c = 2
(b) a = 1, b = 2, c = 1
(c) $a = \frac{5}{6}$, $b = \frac{1}{2}$, $c = \frac{1}{3}$
(d) $a = -\frac{5}{6}$, $b = \frac{1}{2}$, $c = \frac{1}{3}$

BCECE-2007

Ans. (d) : Given,

$$T \propto P^ad^bE^c$$

$$[T] \propto [ML^{-1}T^{-2}]^a [ML^{-3}]^b [ML^2T^{-2}]^c$$

$$M^0L^0T^1 \propto M^{a+b+c} L^{-a-3b+2c} T^{-2a-2c}$$

On comparing powers, we get–

$$a + b + c = 0$$
$$-a - 3b + 2c = 0$$
$$-2a - 2c = 1$$

On solving, we get–

$$a = \frac{-5}{6}, b = \frac{1}{2}, c = \frac{1}{3}$$

391. The refractive index of a material is given by the equation $n = \frac{A+B}{\lambda^2}$, where A and B are constants. The dimensional formula for B is :

(a) $[M^0L^2T^{-1}]$ (b) $[M^0L^{-2}T^0]$
(c) $[M^0L^2T^{-2}]$ (d) $[M^0L^2T^0]$

BCECE-2003

Ans. (d) : Given that, $n = \frac{A+B}{\lambda^2}$

We know that Both side dimension of all terms will be same.

$$[B] = [A] = [n\lambda^2]$$
$$[B] = [M^0L^0T^0][L^2]$$
$$\therefore [B] = [M^0L^2T^0]$$

392. If the dimensions of length are expressed as a $G^x.c^y.h^z$, where G, c and h are the universal gravitational constant, speed of light and planck constant respectively, then–

(a) $x = 1, y = -\frac{3}{2}, z = \frac{1}{2}$
(b) $x = \frac{1}{2}, y = \frac{1}{2}, z = -\frac{3}{2}$
(c) $x = \frac{1}{2}, y = -\frac{3}{2}, z = \frac{1}{2}$
(d) $x = -\frac{3}{2}, y = \frac{1}{2}, z = \frac{1}{2}$

BCECE-2016

Ans. (c) : As per question,

$$[L] = [G^x.c^y.h^z]$$
$$[L] = [G]^x [c]^y [h]^z \quad ....(i)$$

We know,

$$F = \frac{Gm_1m_2}{r^2}$$

$$[G] = \frac{[M^1L^1T^{-2}]}{[M^2]} \times [L^2]$$

Where

$$[G] = [M^{-1}L^3T^{-2}]$$

$$[c] = [LT^{-1}]$$

We know, E = hν

E = Energy, ν = Frequency

h = E/ν

@apna_pdf

$$[h] = \frac{[M^1L^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$$

Now putting the values in eq. (i)

$[M^0L^1T^0] = [M^{-1}L^3T^{-2}]^x \times [LT^{-1}]^y\,[M^1L^2T^{-1}]^z$

$-x + z = 0$

$3x + y + 2z = 1$

$-2x - y - z = 0$

On comparing we get,

$x = \frac{1}{2}, \quad y = \frac{-3}{2}, \quad z = \frac{1}{2}$

393. Two quantities X and Y have different dimensions. Which mathematical operation given below is physically meaningful?

(a) X + Y　　(b) X – Y

(c) X/Y　　(d) None of these

BCECE-2014

Ans. (c) : From the principle of Homogeneity of dimensions, addition, subtraction or equality between two different quantities of different dimensions are not possible but multiplication and division is possible.

394. The dimensional formula of electric potential is

(a) $ML^2T^{-3}A^{-1}$　　(b) $M^{-1}L^2T^{-2}A$

(c) $M^{-1}L^2T^{-2}A^{-1}$　　(d) $ML^2T^{-2}A$

J&K-CET-2013

Ans. (a) : Electric potential = $\frac{\text{Potential energy}}{\text{Charge of particle}}$

Dimension (electric potential) = $\frac{[M^1L^2T^{-2}]}{[T^1A^1]}$

$= [M^1L^2T^{-3}A^{-1}]$

395. When a wave transverses a medium the displacement of a particle located at x at a time t is given by y = asin(bt - cx). Where a, b and c are constants of the wave. Which of the following is a quantity with dimensions?

(a) $\frac{y}{a}$　　(b) bt

(c) cx　　(d) $\frac{b}{c}$

VITEEE-2009

Ans. (d) : y = a sin (bt – cx)

sin(bt – cx) Dimensionless

Therefore,

$[bt] = [M^0L^0T^0]$

$[b] = \left[\frac{1}{t}\right] \Rightarrow [b] = [t^{-1}]$

$[cx] = [M^0L^0T^0]$

$[c] = \left[\frac{1}{x}\right]$

$[c] = [L^{-1}]$

$\left[\frac{b}{c}\right] = \left[\frac{T^{-1}}{L^{-1}}\right] \Rightarrow \left[\frac{b}{c}\right] = [LT^{-1}]$

396. The dimensions of the ratio of magnetic flux (ϕ) and permeability (μ) are :

(a) $[M^0L^1T^0A^1]$

(b) $[M^0L^{-3}T^0A^1]$

(c) $[M^0L^1T^1A^{-1}]$

(d) $[M^0L^2T^0A^1]$

Karnataka CET-2018

VITEEE -2013

Ans. (a) : Dimensions of magnetic flux of

$\phi_B = B.A.\cos\theta$

Where, B = Magnetic field

A = Surface area

θ = Angle between the magnetic field and normal to the surface.

$\phi_B = [M^1L^2T^{-2}I^{-1}]$

Dimension's of permeability $[\mu_0] = [MLT^{-2}A^{-2}]$

$\frac{\phi_B}{\mu} = \frac{[M^1L^2T^{-2}I^{-1}]}{[MLT^{-2}A^{-2}]}$

$= [M^0L^1T^0A^1]$

397. The dimensional formula of physical quantity is $[M^aL^bT^c]$. Then, that physical quantity is :

(a) spring constant if a = 1, b = –1, c = –2

(b) surface tension if a = 1, b = 1, c = –2

(c) force if a =1, b = 1, c = 2

(d) angular frequency if a = 0, b = 0, c = –1

Karnataka CET-2012

Ans. (d) : Given that, the dimension formula for quantity is $[M^aL^bT^c]$

Angular frequency $W = \frac{2\pi}{T}$

$W = [M^0L^0T^{-1}]$

$a = 0, b = 0, c = -1$

398. Out of the following four dimensional quantities, which one qualifies to be called a dimensional constant ?

(a) acceleration due to gravity

(b) surface tension of water

(c) weight of a standard kilogram mass

(d) the velocity of light in vacuum

Karnataka CET-2005

Ans. (d) : The velocity of light in vacuum is constant i.e. 3×10^8 m/s. Hence, it is a dimensional constant.

The physical quantities which have dimensions and a fixed value are known as dimensional constant.

399. The quantities RC and (L/R) (where R, L and C stand for resistance, inductance and capacitance respectively) have the dimension of

(a) force

(b) linear momentum

(c) linear velocity

(d) time

J&K CET- 2009

@apna_pdf

Ans. (d) :

$$RC=\frac{V}{I}\times\frac{Q}{V}=\frac{It}{I}=t$$

dimension of RC = [T]

$$\frac{L}{R}=\frac{\left(\frac{V}{I}\right)\times t}{\left(\frac{V}{I}\right)}=t$$

dimension of $\frac{L}{R}$ = [T]

Both RC and $\frac{L}{R}$ have the dimensions of time.

400. The only mechanical quantity which has negative dimension of mass is

(a) angular momentum
(b) torque
(c) coefficient of thermal conductivity
(d) gravitational constant

J&K CET- 2007

Ans. (d) : Gravitational constant has negative dimension of mass.

Dimensional formula of gravitational constant, (G) $= [M^{-1}L^3\,T^{-2}]$

Dimensional formula of angular momentum, (L) $= [ML^2\,T^{-1}]$

Dimensional formula of Torque, $(\tau) = [ML^2T^{-2}]$

Dimensional formula of thermal conductivity, (k) $= [MLT^{-3}\,K^{-1}]$

401. The dimensions of the quantities in one of the following pairs are the same. Identify the pairs.

(a) Torque and work
(b) Angular momentum and work
(c) Energy and Young's modulus
(d) Light year and time

J&K CET- 2002

Ans. (a) : Dimensional formula of torque $= [ML^2T^{-2}]$

Dimensional formula of work $= [ML^2T^{-2}]$

So, dimensions of torque and work are same.

402. In a gas equation, for one mole of real gas $\left(P+\frac{a}{V^2}\right)(V-b)=RT$, dimensions of constants a and b are

(a) $[L^3], [ML^4T^{-2}]$
(b) $[L], [ML^2T^{-2}]$
(c) $[ML^5T^{-2}], [L^3]$
(d) None of these

J&K CET- 2002, 2001
AIIMS-1999

Ans. (c) : Given that, Real gas equation -

$$\left[P+\frac{a}{V^2}\right](V-b)=RT$$

By the principle of dimension homogeneity

Dimensions of b = dimensions of volume (V)

Dimension (b) $= [L^3]$

Dimensions of a = Dimensions of pressure (P) × Dimension of volume (V^2)

Dimensions of a $= [ML^{-1}\,T^{-2}] \times [L^6] = [ML^5\,T^{-2}]$

$\therefore$ Dimension of constants a and b are $[ML^5T^{-2}]$ and $[L^3]$.

403. Which of the following is dimensionless ?

(a) Universal gravitational constant
(b) Relative permittivity
(c) Relative velocity
(d) Planck's constant

J&K CET- 2000

Ans. (b) : Relative Permittivity is the ratio of the capacitance of a capacitor using that material as a dielectric, compared with a similar capacitor that has vacuum as its dielectric. It is a dimensionless quantity and denoted by ε_r.

$\varepsilon_r=\frac{\varepsilon_m}{\varepsilon_0}$ Where, ε_m is permittivity of the material

So, relative permittivity has no dimension.

404. The dimension of moment of inertia is

(a) $[MLT^2]$
(b) $[ML^2]$
(c) $\left[\frac{M}{T^2}\right]$
(d) [MLT]

J&K CET- 1997

Ans. (b) : Moment of Inertia = Mass × (Radius of Gyration)^2

Dimension of moment of inertia $= [M^1L^0T^0]\times[M^0L^1\,T^0]^2$
$= [M^1\,L^2\,T^0] = [ML^2]$

405. What is the dimensional formula for works?

(a) $[MLT^{-2}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^3T^{-2}]$
(d) $[ML^2T^{-1}]$

J&K-CET-2014

Ans. (b) : Work = Force × displacement

Dimension (W) = Dimension (F) × Dimension (s)

Dimension (W) $= [M^1\,L^1\,T^{-2}] \times [M^0\,L^1\,T^0]$
$= [M^1\,L^2\,T^{-2}]$

406. Which of the following is a dimensionless quantity?

(a) Magnetic flux density
(b) Electric flux density
(c) Lumen flux density
(d) Optical density

J&K-CET-2014

Ans. (d) : The optical density is a property of a transparent medium. It measures the speed of light through that transparent medium.

Optical density $= \log_{10} I_0/I_t$

Where, I_0 = intensity of incident light
I_t = intensity of transmitted light

It is a dimensionless quantity.

407. The flux density of mass is defined as the amount of mass crossing unit area per unit time. The dimension of this quantity is

(a) $[ML^{-2}T^{-1}]$
(b) $[ML^2T^{-1}]$
(c) $[MLT^{-1}]$
(d) $[M^{-1}L^{-2}T]$

J&K-CET-2012

@apna_pdf

Ans. (a) : Flux density of mass $= \dfrac{\text{Amount of mass}}{\text{Area} \times \text{time}}$

Dimension of flux density of mass $= \dfrac{[M]}{[L^2][T]}$

$= [\,ML^{-2}\,T^{-1}]$

408. The dimensional formula $[ML^2T^{-2}]$ represents

OR

The dimensions of energy are

(a) Moment of force (b) Force
(c) Acceleration (d) Momentum

J&K-CET-2017
AIIMS-2002

Ans. (a) : The moment of a force is a measure of its tendency to cause a body to rotate about an axis.

Moment of force = Force × Perpendicular distance from the axis

Dimension of moment of force

$$= \left[ML^1T^{-2}\right] \times \left[M^0L^1T^0\right]$$
$$= \left[M^1L^2T^{-2}\right]$$

409. If μ_0 and ε_0 denote the permeability and permittivity of vacuum, the quantity which carries the unit of $s^2\ m^{-2}$ is

(a) $\sqrt{\mu_0\varepsilon_0}$ (b) $\dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$
(c) $\mu_0\varepsilon_0$ (d) $\dfrac{1}{\mu_0\varepsilon_0}$

J&K-CET-2016

Ans. (c) : Speed of light is vacuum (c) $= \dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$

$$\mu_0\varepsilon_0 = \frac{1}{c^2}$$

$$\text{Dim. } (\mu_0\varepsilon_0) = \frac{1}{\left[LT^{-1}\right]^2} = L^{-2}T^2$$

$\therefore$ Unit of $\mu_0\varepsilon_0 = s^2m^{-2}$

410. Which among the following quantities has dimensions independent of mass and length?

(a) Energy (b) Thrust
(c) Momentum (d) Angular velocity

J&K-CET-2016

Ans. (d) : Dimensions of Energy $= \left[ML^2T^{-2}\right]$

Dimensions of Thrust $= \left[MLT^{-2}\right]$

Dimensions of momentum $= \left[MLT^{-1}\right]$

Dimensions of angular velocity $= \left[M^0L^0T^{-1}\right]$

Hence, dimensions of angular velocity is independent of mass and length.

411. Match the following two columns.

Column 1	Column 2
(a) Elecrical resistance	(p) $ML^3T^{-3}A^{-2}$
(b) Electrical potential	(q) $ML^2T^{-3}A^{-2}$
(c) Specific resistance	(r) $ML^2T^{-3}A^{-1}$
(d) Specific conducatnce	(s) None of these

(a) a-p, b-r, c-q, d-s (b) a-q, b-r, c-p, d-s
(c) a-p, b-q, c-s, d-r (d) a-q, b-s, c-r, d-p

GUJCET 2016

Ans. (b) : Electrical resistance (R) $= \dfrac{[W]}{[Q][I]}$

Dimension of $[R] = [ML^2T^{-3}A^{-2}]$

Electrical potential (V) $= \dfrac{[W]}{[Q]}$

Dimension of $[V] = [ML^2T^{-3}A^{-1}]$

Specific resistance $(\rho) = \dfrac{[R][A]}{[I]}$

Dimension of $[\rho] = [ML^3T^{-3}A^{-2}]$

Specific conductance (G) $= \dfrac{1}{[R]}$

Dimension of $[G] = [M^{-1}L^{-2}T^3A^2]$

412. What is the dimensions of impedance?

(a) $[ML^2T^{-3}I^{-2}]$ (b) $[M^{-1}L^{-2}T^3I^2]$
(c) $[ML^3T^{-3}I^{-2}]$ (d) $[M^{-1}L^{-3}T^3I^2]$

AIIMS-2007

Ans. (a) : Impedance (Z) $= \dfrac{\text{Voltage (V)}}{\text{Current (I)}}$

$$\text{Dimension of } [Z] = \frac{[V]}{[I]} = \frac{\left[M^1L^2T^{-3}A^{-1}\right]}{\left[M^0L^0T^0A^1\right]}$$
$$= [\,M^1L^2T^{-3}A^{-2}\,]$$
$$= [ML^2T^{-3}I^{-2}] \qquad (\because A = I)$$

413. The dimensions of h/e (h = Planck's constant, e = charge on electron) are same as those of

(a) Magnetic Pole Strength
(b) Magnetic Moment
(c) Magnetic field
(d) Magnetic flux

SRMJEE - 2009

Ans. (d) : h = Planck's constant
e = charge on electron

Dimension of $= \dfrac{h}{e} = ?$

$[h] = [ML^2T^{-1}], [e] = [AT]$

$$\left[\frac{h}{e}\right] = \frac{[ML^2T^{-1}]}{[AT]} \Rightarrow [ML^2T^{-2}A^{-1}]$$

= Magnetic flux

@apna_pdf

414. If $T = 2\pi\sqrt{\dfrac{ML^3}{3Yq}}$ then find the dimensions of q. Where T is the time period of bar of mass M, length L and Young modulus Y.

(a) $[L]$ (b) $[L^2]$

(c) $[L^4]$ (d) $[L^3]$

BITSAT-2011

Ans. (c) : Given that,

$$T = 2\pi\sqrt{\frac{ML^3}{3Yq}}$$

On squaring both side

$$\therefore \quad T^2 = 4\pi^2\frac{ML^3}{3Yq}$$

$$q = \frac{4\pi^2 ML^3}{3YT^2} \Rightarrow q = \frac{[ML^3]}{[ML^{-1}T^{-2}][T^2]} = [L^4]$$

415. For the equation $F = A^a v^b d^c$, where F is the force, A is the area, v is the velocity and d is the density, the values of a, b and c are respectively

(a) 1, 2, 1 (b) 2, 1, 1

(c) 1, 1, 2 (d) 0, 1, 1

BITSTA-2014

Ans. (a) : $F = A^a V^b d^c$

$$[MLT^{-2}] = [(L^2)^a][LT^{-1}]^b[(ML^{-3})]^c$$

Comparing pairs of M,L & T, on both sides, we get

$$[MLT^{-2}] = [M^cL^{2a+b-3c}T^{-b}]$$

$c = 1$ and $b = 2$

$2a + b - 3c = 1$

$2a + 2 - 3 \times 1 = 1$

$2a = 2$

$a = 1$

So, the values of a, b & c are 1, 2, 1

416. The correct order in which the dimension of 'Length' increases in the following physical quantities is?

(A) Permittivity (B) Resistance

(C) Magnetic permeability (D) Stress

(a) (A), (B), (C), (D) (b) (D), (C), (B), (A)

(c) (A), (D), (C), (B) (d) (C), (B), (D), (A)

AP EAMCET(Medical)-2004

Ans. (c) : (A) Electrical Permittivity,

$(\varepsilon_0) = [M^{-1}L^{-3}T^4A^2] = -3$

(B) Resistance (R) $= [M^1L^2T^{-3}A^{-2}] \Rightarrow 2$

(C) Magnetic permeability (μ) $= [M^1L^1T^{-2}A^{-2}] \Rightarrow 1$

(D) stress (σ) $= [M^1L^{-1}T^{-2}] \Rightarrow -1$

$\therefore$ The correct order is the (A, D, C, B) dimension of 'length' increase in the following physical quantities.

417. The dimensional formula for strain is same as that of

(a) thrust (b) angle

(c) modulus of elasticity (d) stress

BITSAT-2008

Ans. (b) : Strain is the ratio of change in length to the original length

$$\text{Strain} = \frac{\Delta L}{L} = \frac{[L]}{[L]}$$

So, strain is dimensionless unit.

$$\text{Angle} = \frac{\text{Arc}}{\text{Radius}} = \frac{[L]}{[L]}$$

Angle is also dimensionless as strain.

- Thrust is defined as the force,

So, $F = \text{Mass} \times \text{Acceleration}$

$F = [MLT^{-2}]$

- Modulus of elasticity (Y) $= \dfrac{\text{Stress}}{\text{Strain}}$

So, $Y = \dfrac{F/A}{\Delta L/L} = \dfrac{FL}{A\Delta L}$

$$Y = \frac{[M^1LT^{-2}][L^1]}{[L^2][L^1]} = M^1L^{-1}T^{-2}$$

$Y = [M^1L^{-1}T^{-2}]$

418. The physical quantity which has dimensional formula as that of $\dfrac{\text{Energy}}{\text{Mass} \times \text{Length}}$ is :

(a) force (b) power

(c) pressure (d) acceleration

AP EAMCET(Medical)-2000

Ans. (d) :

$$\frac{\text{Energy}}{\text{mass} \times \text{length}} = \text{Acceleration}$$

and the dimension of Acceleration is

$$\frac{[ML^2T^{-2}]}{[M][L]} = [LT^{-2}]$$

419. Which of the following units denotes the dimensions $[ML^2/Q^2]$, where Q denotes the electric charge?

(a) Wb/m^2 (b) henry (H)

(c) H/m^2 (d) weber (Wb)

AIEEE 2006

Ans. (b) : We know that,

$$\text{Electrical Inductance} = \frac{\phi}{I} = \frac{BA}{I}$$

Where, B = Magnetic field, A = area, I = current

dimension of each–

$$I = \frac{q}{t} = \frac{[QT^{-1}]}{}$$

$A = M^2 = [L^2]$

$B = [MT^{-1}Q^{-1}]$

$$\text{Hence, Dimension of (L)} = \frac{[MT^{-1}Q^{-1}][L^2]}{[QT^{-1}]} = \frac{[ML^2]}{[Q^2]}$$

$$\therefore \quad \boxed{\text{Henry(H)} = ML^2Q^{-2}}$$

Henry is the SI unit of inductance.

@apna_pdf

(d) Error

420. In a screw gauge, there are 100 divisions on the circular scale and the main scale moves by 0.5 mm on a complete rotation of the circular scale. The zero of circular scale lies 6 divisions below the line of graduation when two studs are brought in contact with each other. When a wire is placed between the studs, 4 linear scale divisions are clearly visible while 46th division the circular scale coincide with the reference line. The diameter of the wire is_____$\times 10^{-2}$ mm.

JEE Main-30.01.2023, Shift-I

Ans. (22) :

$$\text{L.C} = \frac{\text{Pitch}}{\text{Number of division on circular scale}}$$

$$= \frac{0.5\,\text{mm}}{100} = 0.005\,\text{mm}$$

Since pitch is 0.5 mm, so there must be 0.5 mm mark on the main scale

The zero of circular scale lies 6 divisions below the line of graduation

So, Zero error is positive then

Zero error = 6 CSD = 6 × 0.005 mm = 0.03 mm

Measured thickness = MSR + (CSR) (L.C)

$= (4 \times 0.5\text{ mm}) + (46)(0.005\text{ mm}) = 2.23\text{ mm}$

Actual thickness = Measured thickness – zero error = 2.23 mm – (0.03 mm) = 2.20 mm = 22×10^{-2} mm

421. If the error in the measurement of radius of a sphere is 2%, then the error in the determination of volume of the sphere will be

(a) 4% (b) 6%

(c) 8% (d) 2%

AP EAMCET-25.09.2020, Shift-II
[AIPMT 2008]
AFMC-2005

Ans. (b) : Given that,

% error in radius = 2%

$$\frac{\Delta r}{r} \times 100 = 2\%$$

$\because$ volume of sphere $= \frac{4}{3}\pi r^3$

log of both side log v = 3 logr

Differentiating both side

$$\frac{dV}{V} = 3\frac{dr}{r}$$

$$\frac{\Delta v}{v} \times 100 = 3\left(\frac{\Delta r}{r}\times 100\right)$$

$$= 3 \times 2\%$$

$$\frac{\Delta v}{v} \times 100 = 6\%$$

$$\frac{\Delta v}{v} = 6\%$$

% error in volume = 6%

422. A certain body weighs 22.42 g and has a measured volume of 4.7 cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then, maximum error in the density will be

(a) 22% (b) 2%

(c) 0.2% (d) 0.02%

[NEET 2021]
AP EMCET(Medical)-2010
[AIPMT 1991]

Ans. (b) : Given that,

Weight of body (m) = 22.42 g

Volume of body (v) = 4.7 cc

Error in mass (Δm) = 0.01 g

Error in volume (Δv) = 0.1 cc

$$\%\text{ error in mass} = \frac{\Delta m}{m} \times 100 = \frac{0.01}{22.42} \times 100$$

$$= \frac{1}{2242} \times 100$$

$$\%\text{ error in volume} = \frac{\Delta v}{v} \times 100$$

$$= \frac{0.1}{4.7} \times 100 = \frac{1}{47} \times 100$$

$$\because \quad \text{Density D} = \frac{\text{mass(m)}}{\text{volume(v)}}$$

%error in density = %error in mass + %error in volume

$$= \frac{1}{2242}\times 100 + \frac{1}{47}\times 100 = 2.17\%$$

Maximum error in density□ 2%

423. The pressure on a square plate is measured by measuring the force on the plate and the length of the sides of the plate. If the maximum errors in the measurement of force and length are respectively 4% and 2 %, then the maximum error in the measurement of pressure is

(a) 1 % (b) 2 %

(c) 6 % (d) 8 %

AIIMS-2017
JCECE-2016
Kerala CEE-2015
VITEEE-2013

Ans. (d) : We know that, $P = \frac{F}{A} = \frac{F}{l^2}$

So maximum error in Pressure (P),

$$\left|\frac{\Delta P}{P}\right|_{\max} = \frac{\Delta F}{F} + \frac{2\Delta l}{l}$$

$$\left(\frac{\Delta P}{P}\times 100\right)_{\max} = \frac{\Delta F}{F}\times 100 + 2\left(\frac{\Delta l}{l}\times 100\right)$$

$$= 4\% + 2\times 2\%$$

$$\left(\frac{\Delta P}{P}\times 100\right)_{\max} = 8\%$$

@apna_pdf

424. **A physical quantity S is related to four observables a, b, c, d, as S $=\frac{\sqrt{ab}}{c^3d^4}$. if the percentage errors of measurement in a, b, c, d, are 2%, 1%, 1% and 1% respectively. then percentage error in the quantity S is.**

(a) 6% (b) 8%

(c) 9% (d) 10%

TS EAMCET 19.07.2022, Shift-I

Ans. (c) : Given that,

$$S=\frac{\sqrt{ab}}{c^3d^4}$$

$$\Rightarrow S=a^{1/2}.b^{1/2}.c^{-3}.d^{-4}$$

$$\frac{\Delta s}{s}\times=\frac{1}{2}\left(\frac{\Delta a}{a}\right)\%+\frac{1}{2}\left(\frac{\Delta b}{b}\right)\%+3\left(\frac{\Delta c}{c}\right)\%+4\left(\frac{\Delta d}{d}\right)\%$$

$$\frac{\Delta s}{s}\%=\frac{1}{2}\times2\%+\frac{1}{2}\times1\%+3\times1\%+4\times1\%$$

$$=1\%+\frac{1}{2}\%+3\%+4\% \quad =8\%+\frac{1}{2}\%$$

$$\frac{\Delta s}{s}\%=8.5\%$$

$$\frac{\Delta s}{s}\%\approx9\%$$

Hence, percentage error in the quantity is 9%.

425. **A Physical quantity is given as $Y = A^{1/2}\ B^{1/3}$. While measuring above quantity, the percentage of errors given for A and B are 2% and 3% respectively. The maximum percentage error while measuring y is**

(a) 6 (b) 4 (c) 5 (d) 2

TS EAMCET 30.07.2022, Shift-I

Ans. (d) : The quantity is given as:

$$Y=A^{1/2}\ B^{1/3}$$

$$\frac{\Delta Y}{Y}\times100=\frac{1}{2}\times\frac{\Delta A}{A}\times100+\frac{1}{3}\times\frac{\Delta B}{B}\times100$$

$$\frac{\Delta A}{A}\times100=2\%$$

$$\frac{\Delta B}{B}\times100=3\%$$

$$\frac{\Delta Y}{Y}=\frac{1}{2}\times2+\frac{1}{3}\times3$$

$$\therefore \quad \frac{\Delta Y}{Y}=2\,\%$$

Therefore, the maximum percentage error while measuring Y is 2%.

426. **A torque meter is calibrated to reference standards of mass, length and time each with 5% accuracy. After calibration, the measured torque with this torque meter will have net accuracy of:**

(a) 15% (b) 25%

(c) 75% (d) 5%

JEE Main-27.07.2022, Shift-I

Ans. (b) : Torque is given by- $\tau = ML^2T^{-2}$

taking log of both side

$$\log\tau=\log M+2\log L+2\log T$$

$$\frac{\Delta\tau}{\tau}=\frac{\Delta M}{M}+2\frac{\Delta L}{L}+2\frac{\Delta T}{T}$$

Maximum error in torque is given by

$$\frac{\Delta\tau}{\tau}\times100=\frac{\Delta M}{M}\times100+2\frac{\Delta L}{L}\times100+2\frac{\Delta T}{T}\times100$$

$$=1\times5\%+2\times5\%+2\times5\%$$

$$\frac{\Delta\tau}{\tau}\times100=25\%$$

Error in torque = 25%

427. **A student in the laboratory measures thickness of a wire using screw gauge. The readings are 1.22 mm, 1.23 mm, 1.19 mm and 1.20 mm. The percentage error is $\frac{x}{121}$%. The value of x is ___.**

JEE Main-28.06.2022, Shift-II

Ans. (150) : From the question

$$D_{mean}=\frac{1.22+1.23+1.19+1.20}{4}=\frac{4.84}{4}=1.21$$

$$\Delta D_{mean}=\frac{|D_2-D_1|+|D_m-D_2|+|D_m-D_3|+|D_m-D_4|}{4}$$

$$\Delta D_{mean}=\frac{0.01+0.02+0.02+0.01}{4}=\frac{0.06}{4}=0.015$$

$$\frac{\Delta D_{mean}}{D_{mean}}\times100=\frac{0.015}{1.21}\times100=\frac{150}{121}\%$$

$\because$ Percentage error is $\frac{x}{121}\%$

Compare this value x = 150

428. **A silver wire has mass (0.6 ± 0.006) g, radius (0.5 ± 0.005) mm and length (4 ± 0.04) cm. The maximum percentage error in the measurement of its density will be**

(a) 4% (b) 3%

(c) 6% (d) 7%

JEE Main-27.06.2022, Shift-I

Ans. (a) : Given,

Mass (M) = (0.6 ± 0.006)g

Radius (R) = (0.5 ± 0.005) cm

Length (L) = (4 ± 0.04)mm

Volume of wire = $\pi r^2 l$

Density is given by D = $\frac{M}{V}=\frac{M}{L^3}$

Maximum percentage error in density

$$\frac{\Delta D}{D}\times100=\frac{\Delta M}{M}\times100+3\frac{\Delta L}{L}\times100$$

$$=\frac{0.006}{0.6}\times100+3\times\frac{0.04}{4}\times100$$

$$\frac{\Delta D}{D}\times100=4\%,\quad \frac{\Delta D}{D}=4\%$$

@apna_pdf

429. If $Z=\dfrac{A^2B^3}{C^4}$, then the relative error in Z will be :

(a) $\dfrac{\Delta A}{A}+\dfrac{\Delta B}{B}+\dfrac{\Delta C}{C}$ (b) $\dfrac{2\Delta A}{A}+\dfrac{3\Delta B}{B}-\dfrac{4\Delta C}{C}$

(c) $\dfrac{2\Delta A}{A}+\dfrac{3\Delta B}{B}+\dfrac{4\Delta C}{C}$ (d) $\dfrac{\Delta A}{A}+\dfrac{\Delta B}{B}-\dfrac{\Delta C}{C}$

JEE Main-25.06.2022, Shift-I

Ans. (c) : Given that,

$$Z=\frac{A^2B^3}{C^4}$$

Error in Z will be

$$\frac{\Delta Z}{Z}\times 100=2\frac{\Delta A}{A}\times 100+3\left(\frac{\Delta B}{B}\times 100\right)+4\left(\frac{\Delta C}{C}\times 100\right)$$

$$\frac{\Delta Z}{Z}=\frac{2\Delta A}{A}+\frac{3\Delta B}{B}+\frac{4\Delta C}{C}$$

430. For $z=a^2x^3y^{1/2}$, where 'a' is a constant. If percentage error in measurement of 'x' and 'y' are 4% and 12%, respectively, then the percentage error for 'z' will be _________%.

JEE Main-25.06.2022, Shift-II

Ans. (18) : Given that,

$z=a^2x^3y^{1/2}$

∵ a = constant

% error in x = 4%

% error in y = 12%

∵ maximum percentage error in z

$$\frac{\Delta z}{z}\times 100=3\frac{\Delta x}{x}\times 100+\frac{1}{2}\frac{\Delta y}{y}\times 100$$

$$=3\times 4\%+\frac{1}{2}\times 12\%$$

$$=12\%+6\%$$

$$\frac{\Delta z}{z}\times 100=18\%$$

431. The maximum error in the measurement of resistance, current and time for which current flows in an electrical circuit are 1%, 2% and 3% respectively. The maximum percentage error in the detection of the dissipated heat will be:

(a) 2 (b) 4

(c) 6 (d) 8

JEE Main-25.07.2022, Shift-II

Ans. (d) : Given,

Error in resistance (R) = 1%

Error in current (I) = 2%

Error in time (T) = 3%

Heat dissipated $H=I^2RT$

Taking log of both side

log H = 2 log I + log R + log π

Diffentiating both side

$$\frac{\Delta H}{H}=2\frac{\Delta I}{I}+\frac{\Delta R}{R}+\frac{\Delta T}{T}$$

$$\frac{\Delta H}{H}\times 100=2\left(\frac{\Delta I}{I}\times 100\right)+\left(\frac{\Delta R}{R}\times 100\right)+\left(\frac{\Delta T}{T}\times 100\right)$$

$$\frac{\Delta H}{H}\times 100=2\times 2\%+1\times 1\%+1\times 3\%$$

$$\frac{\Delta H}{H}\times 100=8\%$$

432. A physical quantity P is related to four observables a,b,c, and d as $P=\dfrac{\sqrt{ab}.d^{\alpha}}{\sqrt{c}}$ (α is constant). The percentage errors in a,b,c and d are 0.5% in each. If the percentage error in P is 2%, then α is–

(a) $\dfrac{5}{2}$ (b) $\dfrac{2}{5}$

(c) $\dfrac{3}{4}$ (d) $\dfrac{3}{2}$

AP EAMCET-07.07.2022, Shift-II

Ans. (a) : Given,

$$P=\frac{\sqrt{ab}\,d^{\alpha}}{\sqrt{c}}$$

$$\frac{\Delta P}{P}\times 100=\left(\frac{1}{2}\frac{\Delta a}{a}+\frac{1}{2}\frac{\Delta b}{b}+\alpha\frac{\Delta d}{d}+\frac{1}{2}\frac{\Delta c}{c}\right)\times 100$$

$$\frac{\Delta P}{P}\times 100=\frac{1}{2}\times 0.5+\frac{1}{2}\times 0.5+\alpha\times 0.5+\frac{1}{2}\times 0.5$$

$$2=\frac{1}{4}+\frac{1}{4}+\frac{\alpha}{2}+\frac{1}{4}$$

$$2=\frac{3}{4}+\frac{\alpha}{2}$$

$$\boxed{\therefore\ \alpha=\frac{5}{2}}$$

433. Given : The percentage error in the measurements of A, B, C and D are respectively, 4%, 2%. 3% and 1%. The relative error in $Z=\dfrac{A^4B^{1/3}}{CD^{3/2}}$

(a) $\dfrac{127}{2}\%$ (b) $\dfrac{127}{5}\%$

(c) $\dfrac{127}{6}\%$ (d) $\dfrac{127}{7}\%$

WB JEE 2022

Ans. (c) : The percentage error in the measurements A,B,C and D are 4%, 2%, 3% and 1%

Relative error (Z) = $\dfrac{A^4B^{1/3}}{CD^{3/2}}$

$$\frac{\Delta Z}{Z}\times 100=\left(4\frac{\Delta A}{A}+\frac{1}{3}\frac{\Delta B}{B}+\frac{\Delta C}{C}+\frac{3}{2}\frac{\Delta D}{D}\right)\times 100\%$$

$$\frac{\Delta Z}{Z}\times 100=\left(4\times 4+\frac{1}{3}\times 2+3+\frac{3}{2}\times 1\right)\%$$

@apna_pdf

$$\frac{\Delta Z}{Z}\times 100=\left(\frac{16}{1}+\frac{2}{3}+\frac{3}{1}+\frac{3}{2}\right)\%$$

$$\frac{\Delta Z}{Z}\times 100=\left(\frac{96+4+18+9}{6}\right)\%$$

$$\frac{\Delta Z}{Z}\times 100=\frac{127}{6}\%$$

434. Let the percentage error in the measurement of three quantities A_1 = BC A_2 = B/C and A_3 = B^2C be Δ_1, Δ_2 and Δ_3 respectively, where B and C are two measurable quantities. Which of the following is true?

(a) $\Delta_1 > \Delta_2 > \Delta_3$
(b) $\Delta_1 = \Delta_2 > \Delta_3$
(c) $\Delta_1 = \Delta_2 < \Delta_3$
(d) $\Delta_1 = \Delta_2 = \Delta_3$

Assam CEE-31.07.2022

Ans. (c) :

Given, $A_1 = BC$

$$A_2=\frac{B}{C}$$

$$A_3 = B^2C$$

$$\Delta_1=\left(\frac{\Delta A_1}{A_1}\times 100\right)=\left(\frac{\Delta B}{B}\times 100\right)+\left(\frac{\Delta C}{C}\times 100\right)$$

$$\Delta_2=\left(\frac{\Delta A_2}{A_2}\times 100\right)=\left(\frac{\Delta B}{B}\times 100\right)+\left(\frac{\Delta C}{C}\times 100\right)$$

$$\Delta_3=\left(\frac{\Delta A_3}{A_3}\times 100\right)=2\left(\frac{\Delta B}{B}\times 100\right)+\left(\frac{\Delta C}{C}\times 100\right)$$

Hence, $\Delta_1 = \Delta_2 < \Delta_3$

435. If the percentage errors in the measurements of mass, length and time are 1%, 2% and 3% respectively, then the maximum permissible error in the measurement of the acceleration of a particle is

(a) 8%
(b) 9%
(c) 6%
(d) 10%
(e) 2%

Kerala CEE 2021

Ans. (a) : Given That,

Error in Mass = 1%

Length (L) = 2%

Time (t) = 3%

$$\text{accelration}=\frac{L}{t^2}$$

$$\text{Accelration Error }\%=\frac{\Delta L}{L}\times 100+2\frac{\Delta t}{t}\times 100$$

$= 2\% + 2\times 3\%$

$= 8\%$

So, Maximum possible error in the measurement of the acceleration of particle is 8%.

436. In the experiment of Ohm's law, a potential difference of 5.0 V is applied across the end of a conductor of length 10.0 cm and diameter of 5.00 mm. The measured current in the conductor is 2.00 A. The maximum permissible percentage error in the resistivity of the conductor is

(a) 3.9
(b) 8.4
(c) 7.5
(d) 3.0

[JEE Mains- 2021, 18 March Shift-I]

Ans. (a) : We know that,

$V = IR$, and $R = \rho\dfrac{l}{A}$

So, $$V = I\times\left(\frac{\rho l}{A}\right)$$

$$\rho=\frac{VA}{lI}\quad ....(i)$$

We know,

$$A=\frac{\pi d^2}{4}$$

Puting the value of A eqn (i)

$$\rho=\frac{V\pi d^2}{4Il}$$

$$\because\quad \frac{\Delta\rho}{\rho}=\frac{\Delta V}{V}+\frac{\Delta I}{I}+\frac{\Delta l}{l}+2\frac{\Delta d}{d}$$

$$\frac{\Delta\rho}{\rho}=\frac{0.1}{5}+\frac{0.01}{2}+\frac{0.1}{10}+2\times\frac{0.01}{5}$$

$$\frac{\Delta\rho}{\rho}=0.02+0.005+0.01+0.004$$

$$\frac{\Delta\rho}{\rho}=0.039$$

$$\frac{\Delta\rho}{\rho}\times 100=0.039\times 100=3.9\%$$

437. The error in the measurement of the length and the breadth of a rectangular table is 1%. If the length and breadth of the table are 1m and 50 cm respectively, then the area of the table including error is

(a) $(0.5\pm 0.1)\text{m}^2$
(b) $(0.5\pm 0.01)\text{m}^2$
(c) $(5000\pm 10)\text{cm}^2$
(d) $(5000\pm 1)\text{cm}^2$

TS EAMCET 06.08.2021, Shift-II

Ans. (b) : According to the question,

Length, $= (l\pm 0.01)$m

Breadth, b = (0.5 ± 0.01)m

Area, $A = \ell\times b = 0.5\text{m}^2$

$$\&\quad \frac{\Delta A}{A}=\frac{\Delta\ell}{\ell}+\frac{\Delta b}{b}$$

$$\Rightarrow \Delta A = A\left(\frac{\Delta\ell}{\ell}+\frac{\Delta b}{b}\right)\Rightarrow \Delta A = 0.5\left(\frac{\Delta\ell}{\ell}+\frac{\Delta b}{b}\right)$$

$$\Rightarrow \Delta A = 0.5\left(\frac{1}{100}+\frac{1}{100}\right)\quad\Rightarrow\quad \Delta A = 0.01\text{ m}^2$$

$$\Rightarrow A = (0.5\pm 0.01)\text{m}^2$$

@apna_pdf

438. Consider a physical quantity Z expressed as $Z = \dfrac{AB^{\frac{1}{2}}}{C^2}$. If the relative error in the magnitudes of A, B and C is 1% then the relative error in Z will be

(a) 0.5% (b) 3.5%

(c) 1% (d) $2\sqrt{2}\%$

TS EAMCET 04.08.2021, Shift-II

Ans. (b) : Physical quantity Z expressed as, $Z = \dfrac{AB^{1/2}}{C^2}$

Relative error in Z, $\dfrac{\Delta Z}{Z} = \dfrac{\Delta A}{A} + \dfrac{1}{2}\dfrac{\Delta B}{B} + 2\dfrac{\Delta C}{C}$

$$\frac{\Delta Z}{Z}\times 100 = \left(\frac{\Delta A}{A}\times 100\right) + \frac{1}{2}\left(\frac{\Delta B}{B}\times 100\right) + 2\left(\frac{\Delta C}{C}\right)$$

$$\left(\frac{\Delta Z}{Z}\times 100\right) = (1) + \left(\frac{1}{2}\times 1\right) + (2\times 1)$$

$$= 1 + \frac{1}{2} + 2 = \frac{2+1+4}{2}$$

$$= \frac{7}{2}$$

$$= 3.5\%$$

$$\left(\frac{\Delta Z}{Z}\times 100\right) = 3.5\%$$

∴ Relative error in Z will be 3.5%

439. Consider a series of measurements of the length of a box in an experiment. The readings are 2.4 m, 25.5 m, 2.8 m, 3.0 m. What would be the relative error?

(a) 0.110 (b) 0.089

(c) 0.079 (d) 0.072

TS EAMCET 06.08.2021, Shift-I

Ans. (d) :

$$l_m = \frac{l_1 + l_2 + l_3 + l_4 + l_5}{5} = \frac{2.4 + 2.5 + 2.6 + 2.8 + 3.0}{5}$$

$$l_m = 2.66$$

$$\Delta l_1 = l_1 - l_m = 2.4 - 2.66 = -0.26$$

$$\Delta l_2 = l_2 - l_m = 2.5 - 2.66 = -0.16$$

$$\Delta l_3 = l_3 - l_m = 2.6 - 2.66 = -0.06$$

$$\Delta l_4 = l_4 - l_m = 2.8 - 2.66 = +0.14$$

$$\Delta l_5 = l_5 - l_m = 3.0 - 2.66 = +0.34$$

$$\Delta l_m = \frac{|\Delta l_1| + |\Delta l_2| + |\Delta l_3| + |\Delta l_4| + |\Delta l_5|}{5}$$

$$= \frac{0.26 + 0.16 + 0.06 + 0.14 + 0.34}{5} = 0.192\text{m}$$

Relative error $= \dfrac{\Delta l_m}{l_m} = \dfrac{0.192}{2.66} = 0.072$

440. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively, the error in measurement of acceleration due to gravity is_____

(a) 4 % (b) 5 % (c) 6 % (d) 7 %

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (d) : We know that ,

$$T = 2\pi\sqrt{\frac{l}{g}} \quad g = \frac{4\pi^2 l}{T^2}$$

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\left|\frac{\Delta T}{T}\right|$$

$$\frac{\Delta l}{l}\times 100 = 1\% \text{ and } \frac{\Delta T}{T}\times 100 = 3\%$$

$$\frac{\Delta g}{g}\times 100 = 1\% + 2\times 3\% = 1\% + 6\% = 7\%$$

Hence, the error in measurement of acceleration due to gravity is 7%.

441. In an experiment, four quantities a, b, c, d are measured with percentage errors 2%, 1%, 3% and 5% respectively. Quantity p is measured as $P = \dfrac{a^2b^2}{cd}$. Find the percentage error in measuring P.

(a) 10% (b) 15%

(c) 14% (d) 12%

AP EAMCET-23.08.2021, Shift-I

Ans. (c) : Given that,

$$P = \frac{a^2b^2}{cd}$$

Percentage errors:-

$$\frac{\Delta a}{a}\times 100 = 2\%$$

$$\frac{\Delta b}{b}\times 100 = 1\%$$

$$\frac{\Delta c}{c}\times 100 = 3\%$$

$$\frac{\Delta d}{d}\times 100 = 5\%$$

$$\therefore \frac{\Delta P}{P}\times 100 = 2\left(\frac{\Delta a}{a}\times 100\right) + 2\left(\frac{\Delta b}{b}\times 100\right) + \left(\frac{\Delta c}{c}\times 100\right) + \left(\frac{\Delta d}{d}\times 100\right)$$

$$\frac{\Delta P}{P}\times 100 = (2\times 2) + (2\times 1) + 3 + 5$$

$$\frac{\Delta P}{P}\times 100 = 4 + 2 + 3 + 5$$

$$\frac{\Delta P}{P}\times 100 = 14\%$$

So, percentage error in measuring P is 14%.

442. Zero error belongs to the category of:

(a) Constant errors (b) Instrumental errors

(c) Personal errors (d) Random errors

AP EAMCET-24.08.2021, Shift-II

Ans. (b) : Instrumental errors:- It is the errors due to imperfect design or calibration of the measuring instrument. Zero error is the instrumental error.

- **Random error:–** Measurements lack precision, but cluster around accurate value.

@apna_pdf

443. When two resistors of resistances $R_1 = (200 \pm 2)$ Ω and $R_2 = (400 \pm 4)$ Ω are connected in series, the equivalent resistance of the combination is ______

(a) $(800 \pm 7)\ \Omega$ (b) $(600 \pm 2)\ \Omega$
(c) $(600 \pm 6)\ \Omega$ (d) $(200 \pm 2)\ \Omega$

AP EAMCET-25.08.2021, Shift-I

Ans. (c) : Given that,

Resistances $R_1 = (200\pm2)\Omega$, $R_2=(400\pm4)\Omega$

When two resistances connected in series then equivalent resistance is-

$R = R_1 + R_2$

$\therefore\ R = (200 \pm 2) + (400 \pm 4)$

$R = (600 \pm 6)\Omega$

444. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of L is 1.0 m from metre scale having a minimum division of 1mm and time of one complete oscillation is 1.95 s measured from stopwatch of 0.01 s resolution. The percentage error in the determination of g will be

(a) 1.13% (b) 1.03%
(c) 1.33% (d) 1.30%

JEE Main-24.02.2021, Shift-II

Ans. (a) : Given that,

Measured value of L = 1.0 m, ΔL = 1mm = 0.001m

Time of one complete oscillation (T) = 1.95 sec,

ΔT = 0.01 sec

By given formula,

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

$$g = 4\pi^2\ \frac{L}{T^2}$$

$$\frac{\Delta g}{g}\times100 = \left(\frac{\Delta L}{L}+2\frac{\Delta T}{T}\right)\times100$$

$$\frac{\Delta g}{g}\times100 = \left(\frac{1\text{mm}}{1\text{m}}+2\times\frac{0.01}{1.95}\right)\times100$$

$$\frac{\Delta g}{g}\times100 = \left(\frac{0.001\text{m}}{1\text{m}}+\frac{0.02}{1.95}\right)\times100$$

$$\frac{\Delta g}{g}\times100 = 0.1+\frac{2}{1.95}$$

$$\frac{\Delta g}{g}\times100 = 0.1+1.025\ = 1.125$$

$$\frac{\Delta g}{g}\times 100 = 1.13\%$$

445. The resistance $R = \frac{V}{I}$, where V = (50 ± 2)V and I = (20 ± 0.2)A. The percentage error in R is x%. The value of x to the nearest integer is………

JEE Main-16.03.2021, Shift-I

Ans. (5) : Given,

V = (50 ± 2) V, I = (20 ± 0.2)A,

V = 50, ΔV =2, I = 20, ΔI = 0.2

$$R = \frac{V}{I},$$

$$\therefore\ \frac{\Delta R}{R} = \frac{\Delta V}{V}+\frac{\Delta I}{I}$$

$$\frac{\Delta R}{R} = \frac{2}{50}+\frac{0.2}{20}$$

$$\frac{\Delta R}{R} = 0.04+0.01 = 0.05$$

$$\frac{\Delta R}{R}\times100 = (0.05\times100)\%$$

$$\frac{\Delta R}{R}\times100=5\%$$

$$\boxed{\therefore\ x = 5}$$

446. In order to determine the Young's modulus of a wire of radius 0.2 cm (measured using a scale of least count =0.001cm) and length 1m (measured using a scale of least count =1mm), a weight of mass 1kg (measured using a scale of least count = 1g) was hanged to get the elongation of 0.5 cm(measured using a scale of least count 0.001 cm).What will be the fractional error in the value of Young's modulus determined by this experiment ?

(a) 0.14% (b) 0.9% (c) 9% (d) 1.4%

JEE Main-16.03.2021, Shift-II

Ans. (d) : Given,

r = 0.2 cm, Δr = 0.001 cm

L = 1m, ΔL = 1mm = 0.001m

m = 1 kg, Δm = 1g.

l = 0.5 cm, Δl = 0.001cm

$$Y = \frac{FL}{Al}$$

$$Y = \frac{mgL}{\pi r^2 l}$$

$$\frac{\Delta Y}{Y} = \frac{\Delta m}{m}+\frac{\Delta g}{g}+\frac{\Delta L}{L}+2\times\frac{\Delta r}{r}+\frac{\Delta l}{l}$$

$$\frac{\Delta Y}{Y} = \frac{1\text{g}}{1\text{kg}}+0+\frac{0.001\text{m}}{1\text{m}}+2\times\frac{0.001}{0.2}+\frac{0.001\text{cm}}{0.5\text{cm}}$$

$$\frac{\Delta Y}{Y} = \frac{1}{1000}+\frac{1}{100}+\frac{2}{10^3}+\frac{1}{10^3}$$

$$\frac{\Delta Y}{Y} = \frac{1+10+2+1}{1000} = \frac{14}{1000}$$

$$\frac{\Delta Y}{Y}\times100 = \left(\frac{14}{1000}\times100\right)\% = 1.4\%$$

@apna_pdf

447. Three students S_1, S_2 and S_3 perform an experiment for determining the acceleration due to gravity (g) using a simple pendulum. They use different lengths of pendulum and record time for different number of oscillations. The observations are as shown in the table.

Student No.	Length of pendulum (cm)	No. of oscillation (n)	Total time for n oscillations	Time period (s)
1.	64.0	8	128.0	16.0
2.	64.0	4	64.0	16.0
3.	20.0	4	36.0	9.0

(Least count of length = 0.1m, least count for time = 0.1s) If E_1, E_2, and E_3 are the percentage errors in g for students 1, 2 and 3 respectively, then the minimum percentage error is obtained by student number ……… .

JEE Main-22.07.2021, Shift-II

Ans. (1) :

$$\because \qquad T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \qquad g = \frac{4\pi^2 l}{T^2}$$

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$$

$$\Delta T = \frac{\text{Least count of time}(\Delta T_0)}{\text{No. of oscillation}(n)}$$

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T_0}{nT}$$

$$\therefore \quad \text{For} \quad S_1 \rightarrow \frac{\Delta g}{g} = \left(\frac{0.1\,\text{m}}{64\,\text{cm}} + \frac{2\times0.1}{128}\right)\times 100 = 0.3125\%$$

$$S_2 \rightarrow \frac{\Delta g}{g} = \left(\frac{0.1\,\text{m}}{64\,\text{cm}} + \frac{2\times0.1}{64}\right)\times 100 = 0.4688\%$$

$$S_3 \rightarrow \frac{\Delta g}{g} = \left(\frac{0.1\,\text{m}}{20\,\text{cm}} + \frac{2\times0.1}{36}\right)\times 100 = 1.056\%$$

Therefore, minimum % error is obtained by student S_1

448. If the length of the pendulum in pendulum clock increases by 0.1%, then the error in time per day is

(a) 86.4 s (b) 4.32 s
(c) 43.2 s (d) 8.64 s

JEE Main-26.08.2021, Shift-II

Ans. (c) : Given that,

Length of pendulum = L
Length increased = 0.1%

$$\text{Time period, } T = 2\pi\sqrt{\frac{L}{g}} = 1 \text{ day}$$

Time in a day = 1 × 60 × 60 × 24 sec.

So,

New length, L = L + 0.001 L

$$\text{New Time period, } T' = \sqrt{\frac{L}{g}} = \sqrt{\frac{1.001L}{g}}$$

$$T' = \sqrt{1.001} \times \sqrt{\frac{L}{g}}$$

$$T' = \sqrt{1.001}\, T$$

Now, Time in a day, $T' = \sqrt{1.001} \times 60 \times 60 \times 24$

Error in a day

$$= \sqrt{1.001} \times 60 \times 60 \times 24 - 1 \times 60 \times 60 \times 24$$

$$= 60 \times 60 \times 24\,(\sqrt{1.001} - 1)$$

$$= 60 \times 60 \times 24\,(1.0005 - 1)$$

$$= 60 \times 60 \times 24 \times 0.0005$$

$$= 43.2 \text{ sec}$$

449. A student determined Young's modulus of elasticity using the formula $Y = \frac{MgL^3}{4bd^3\delta}$. The value of g is taken to be 9.8 m/s^2, without any significant error, his observations are as following.

Physical quantity	Least count of the equipment used for measurement	Observed value
Mass (M)	1g	2kg
Length of bar (L)	1mm	1m
Breadth of bar (b)	0.1 mm	4cm
Thickness of bar (d)	0.01 mm	0.4cm
Depression (δ)	0.01 mm	5mm

Then, the fractional error in the measurement of Y is

(a) 0.0083 (b) 0.0155
(c) 0.155 (d) 0.083

JEE Main-01.09.2021, Shift-II

Ans. (b) : Given,

$$Y = \frac{MgL^3}{4bd^3\delta} \text{ (Young's modulus of elasticity)}$$

$$\frac{\Delta Y}{Y} = \frac{\Delta M}{M} + \frac{\Delta g}{g} + 3\frac{\Delta L}{L} + \frac{\Delta b}{b} + 3\frac{\Delta d}{d} + \frac{\Delta\delta}{\delta}$$

$$= \frac{1\text{g}}{2\text{kg}} + 0 + 3\times\frac{1\text{mm}}{1\text{m}} + \frac{0.1\,\text{mm}}{4\text{cm}} + 3\times\frac{0.01\,\text{mm}}{0.4\,\text{cm}} + \frac{0.01\,\text{mm}}{5\text{mm}}$$

$$= \frac{1}{2000} + 0 + 3\times\frac{1}{1000} + \frac{0.1}{40} + 3\times\frac{0.01}{4} + \frac{0.01}{5}$$

$= 0.0035 + 0.0025 + 0.0075 + 0.002$

$= 0.0155.$

450. Time intervals measured by a clock give the following readings 1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error of the observations?

(a) 2% (b) 4%
(c) 16% (d) 1.6%

[NEET (Oct.) 2020]

@apna_pdf

Ans. (d) : Error = Reading value – mean value

$$\text{Mean value} = \frac{\text{Sum of observation}}{\text{No. of observation}}$$

$$= \frac{1.25+1.24+1.27+1.21+1.28}{5}$$

$$= \frac{6.25}{5}$$

$= 1.25$ sec

Error in each reading, $E_1 = 1.25 - 1.25 = 0$

$E_2 = 1.24 - 1.25 = -0.01$

$E_3 = 1.27 - 1.25 = 0.02$

$E_4 = 1.21 - 1.25 = -0.04$

$E_5 = 1.28 - 1.25 = 0.03$

$$\text{Relative error} = \frac{\text{Sum of absolute error}}{\text{Mean value} \times 5}$$

$$= \frac{|E_1|+|E_2|+|E_3|+|E_4|+|E_5|}{1.25\times 5}\times 100\%$$

$$= \frac{0+0.01+0.02+0.04+0.03}{1.25\times 5}\times 100\%$$

$$= \frac{0.1}{1.25\times 5}\times 100\%$$

$= 1.6\%$

451. A physical quantity z depends on four observables a,b,c and d, as $z = \frac{a^2b^{2/3}}{\sqrt{c}d^3}$. The percentages of error in the measurement of a,b,c and d are 2%, 1.5%, 4% and 2.5% respectively. The percentage of error in z is

(a) 13.5%
(b) 16.5%
(c) 14.5%
(d) 12.25%

JEE Main-05.09.2020, Shift-I

Ans. (c) : Given that,

The percentage of error in the measurement of a,b,c and d are 2%, 1.5%, 4%, and 2.5%

$$z = \frac{a^2b^{2/3}}{\sqrt{c}\,d^3}$$

$$\frac{\Delta z}{z}\times 100 = \frac{2\Delta a}{a}\times 100 + \frac{2}{3}\frac{\Delta b}{b}\times 100 + \frac{1}{2}\frac{\Delta c}{c}\times 100 + 3\frac{\Delta d}{d}\times 100$$

$$\frac{\Delta z}{z}\times 100 = 2\times 2\% + \frac{2}{3}\times 1.5\% + \frac{1}{2}\times 4\% + 3\times 2.5\%$$

$$\frac{\Delta z}{z}\times 100 = 4\% + 1\% + 2\% + 7.5\%$$

$$\frac{\Delta z}{z}\times 100 = 14.5\%$$

452. The density of a solid metal sphere is determined by measuring its mass and its diameter. The maximum error in the density of the sphere is $\left(\frac{x}{100}\right)\%$. If the relative errors in measuring the mass and the diameter are 6.0% and 1.5% respectively, the value of x is …… .

JEE Main-06.09.2020, Shift-I

Ans. (1050) : We know that

$\because \quad \rho = \frac{m}{V}$ ......(i)

$$\left\{\because V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3\right\}$$

$\therefore \quad \rho = k\left(\frac{m}{d^3}\right)$

$$\frac{\Delta\rho}{\rho}\times 100 = \frac{\Delta m}{m}\times 100 + 3\frac{\Delta d}{d}\times 100$$

$$\frac{\Delta\rho}{\rho}\times 100 = 6 + 3\times 1.5 = 10.5\%$$

$$\left(\frac{x}{100}\right)\% = \left(\frac{1050}{100}\right)\%$$

$\therefore \quad x = 1050$

453. If absolute error is 0.05 m for a measured length of 5m. What is the percentage error?

(a) 1%
(b) 2%
(c) 3%
(d) 4%

TS-EAMCET-09.09.2020, Shift-2

Ans. (a) : Percentage error in length is given as–

$$\left(\frac{\Delta l}{l}\right)\% = \frac{\Delta l}{l}\times 100$$

$\because l = 5\text{m}, \ \Delta l = 0.05\text{m}$

$$\therefore \left(\frac{\Delta l}{l}\right)\% = \left(\frac{0.05}{5}\right)\times 100$$

$$\left(\frac{\Delta l}{l}\right)\% = \left(\frac{5}{5}\right)$$

$$\boxed{\left(\frac{\Delta l}{l}\right)\% = 1\%}$$

454. At normal incidence, a beam of light propagating in vacuum reflects of an interface with a medium of refractive index n = 3. The fraction of energy reflected R is given as $R = \left(\frac{n-1}{n+1}\right)^2$. If the fractional error in the value of n is 1%, the fractional error in the estimation of R is:

(a) 1.5%
(b) 2.0%
(c) 2.5%
(d) 0.5%

TS EAMCET 29.09.2020, Shift-II

Ans. (a) : Given,

Fraction of energy reflected, $R = \left(\frac{n-1}{n+1}\right)^2$

where, n = 3

$$\frac{\Delta n}{n}\times 100 = 1\%$$

Fractional error in R → $\frac{\Delta R}{R}\times 100 = ?$

$$R = \left(\frac{n-1}{n+1}\right)^2$$

@apna_pdf

Take log both side,

$$\log R = \log\left(\frac{n-1}{n+1}\right)^2 = 2\left(\log(n-1)-\log(n+1)\right)$$

by differentiating –

$$d(\log R) = 2\left[\frac{1}{n-1}dn - \frac{1}{n+1}dn\right]$$

$$\frac{1}{R}dR = 2dn\left[\frac{n+1-n+1}{(n-1)(n+1)}\right]$$

$$\frac{dR}{R} = 2dn \times \frac{2}{n^2-1}$$

$$\frac{dR}{R} = \frac{4n}{n}\times dn \times \frac{1}{n^2-1}$$

$$\frac{dR}{R} = \frac{4n}{n^2-1}\times\frac{dn}{n}$$

Put the value of n = 3

$$\frac{dR}{R}\times 100 = \frac{4\times 3}{9-1}\frac{\Delta n}{n}\times 100 \qquad \left(\because \frac{\Delta n}{n} = \frac{dn}{n}\right)$$

$$\frac{dR}{R}\times 100 = 1.5\times(1\%)$$

$$\frac{dR}{R}\times 100 = 1.5\%$$

Also like–

$$\frac{\Delta R}{R}\times 100 = 1.5\% \quad \left(\because \frac{dR}{R} = \frac{\square R}{R}\right)$$

Hence, the value of $\frac{\Delta R}{R}\times 100 = 1.5\%$

455. In five successive measurements, the mass of a ball is measured to be 2.61 g, 2.58 g, 2.40 g, 2.73 g and 2.80 g. The absolute error in the measurement is

(a) 0.09 g (b) 0.07 g

(c) 0.11 g (d) 0.13 g

TS-EAMCET-10.09.2020, Shift-2

Ans. (c) : The mean mass of the ball is

$$M_{mean} = \frac{\sum_{i=1}^{n} m_i}{n} = \frac{[m_1+m_2+m_3+m_4+m_5]}{5}$$

Where– $m_1 = 2.61$ g

$m_2 = 2.58$ g

$m_3 = 2.40$ g

$m_4 = 2.73$ g

$m_5 = 2.80$ g

$$M_{mean} = \frac{(2.61+2.58+2.40+2.73+2.80)}{5}$$

$$= \frac{13.12}{5} = 2.624\text{g}$$

$M_{mean} = 2.62$g

The absolute error in the measurement–

$\Delta M_1 = 2.62 - 2.61 = 0.01$g

$\Delta M_2 = 2.62 - 2.58 = 0.04$g

$\Delta M_3 = 2.62 - 2.40 = 0.22$g

$\Delta M_4 = 2.62 - 2.73 = -0.11$g

$\Delta M_5 = 2.62 - 2.80 = -0.18$g

Mean absolute error in measurement of mass is given as–

$$\Delta M_{mean} = \frac{\sum_{i=1}^{n}|\Delta M_i|}{n}$$

$$\Delta M_{mean} = \frac{\Delta M_1+\Delta M_2+\Delta M_3+\Delta M_4+\Delta M_5}{5}$$

$$\Delta M_{mean} = \frac{0.01+0.04+0.22+0.11+0.18}{5}$$

$$\Delta M_{mean} = \frac{0.56}{5} = 0.112\text{g} \Rightarrow \Delta M_{mean} = 0.11\text{g}$$

456. To estimate g from $g = 4\pi^2\frac{L}{T^2}$, error in measurement of L is ±2% and error in measurement of T is ±3%. The error in estimated g will be

(a) ±8% (b) ±5%

(c) ±3% (d) ±6%

AP EAMCET (18.09.2020) Shift-II

Ans. (a) : Given, $g = \frac{4\pi^2 L}{T^2}$

The percentage error in measurement of 'g' is given as–

$$\left(\frac{\Delta g}{g}\times 100\right)\% = \left(\frac{\Delta L}{L}\times 100\right)\% + 2\times\left(\frac{\Delta T}{T}\times 100\right)\%$$

$$\because \left(\frac{\Delta L}{L}\times 100\right)\% = \pm 2\% \quad , \quad \left(\frac{\Delta T}{T}\times 100\right)\% = \pm 3\%$$

$$\therefore \left(\frac{\Delta g}{g}\times 100\right)\% = \pm 2\% + 2\times(\pm 3\%)$$

$$\left(\frac{\Delta g}{g}\times 100\right)\% = 2\% + 6\%$$

$$\boxed{\left(\frac{\Delta g}{g}\times 100\right)\% = \pm 8\%}$$

457. If Voltage V= (200 ± 8) V and current I = (20 ± 0.5) A, the percentage error in resistance R is

(a) 5.2% (b) 25%

(c) 3% (d) 6.5%

COMEDK 2020

Ans. (d) : Given,

Voltage, $V = (200\pm 8)$ V

Current, $I = (20\pm 0.5)$ A

$$R = \frac{V}{I} = \frac{200}{20} = 10\Omega \quad \text{(ohm's law)}$$

$$\frac{\Delta R}{R} = \left(\frac{\Delta V}{V}+\frac{\Delta I}{I}\right) = \left(\frac{8}{200}+\frac{0.5}{20}\right) = \frac{13}{200} = 0.065$$

% of error in $R = \frac{\Delta R}{R}\times 100 = 0.065 \times 100 = 6.5\%$

@apna_pdf

458. A cylindrical wire has a mass (0.3 ± 0.003) g, radius (0.5 ± 0.005) mm and length (6 ± 0.06) cm. The maximum percentage error in the measurement of its density is :

(a) 1 (b) 2
(c) 3 (d) 4

Karnataka CET-2020

Ans. (d) : Density $(\rho) = \frac{m}{\pi r^2 L}$

So, max. % error in value ρ,

$$\frac{\Delta\rho}{\rho}\times 100 = \left[\frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta L}{L}\right]\times 100$$

$$\frac{\Delta\rho}{\rho}\times 100 = \left[\frac{0.003}{0.3} + 2\times\frac{0.005}{0.5} + \frac{0.06}{6}\right]\times 100$$

$$= [0.01 + 0.02 + 0.01]\times 100$$

$$\frac{\Delta\rho}{\rho}\times 100 = 4\%$$

459. The power in an electrical circuit for a current of 5 ± 0.4A and voltage 10 ± 0.2 V is measured at 10% error. To measure the power at 5% error the current should be measured at an error of

(a) 5% (b) 2%
(c) 10% (d) 3%
(e) 4%

Kerala CEE 2020

Ans. (d) : As we know,

P = VI

$$\frac{\Delta P}{P}\times 100 = \frac{\Delta V}{V}\times 100 + \frac{\Delta I}{I}\times 100$$

$$5\% = \frac{0.2}{10}\times 100 + \frac{\Delta I}{I}\times 100$$

$$\boxed{\frac{\Delta I}{I}\times 100 = 3\%}$$

[Assume at error in V will not change]

460. A physical quantity $X = \frac{A^2B}{C^{1/3}\sqrt{D}}$ is calculated by using measured quantities A, B C and B. If errors in the measurement of A, B, C, and D are 1%, 2%, 3% and 4% respectively, then the percentage of error in the measurement of X will be

(a) 3% (b) 5%
(c) 7% (d) 10%

Assam CEE-2020

Ans. (c) : Given $x = \left(\frac{A^2B}{C^{1/3}\sqrt{D}}\right)$

taking log and differentiating

$$\log x = 2\log A + \log B - \frac{1}{3}\log c - \frac{1}{2}\log D$$

for maximum error is +ve sign

$$\therefore \frac{\Delta x}{x} = 2\frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta C}{3C} + \frac{1}{2}\frac{\Delta D}{D}$$

$$\therefore \text{Maximum percentage error} = \left|\frac{\Delta x}{x}\right|\times 100$$

$$= 2\left[\frac{\Delta A}{A}\times 100\right] + \left[\left(\frac{\Delta B}{B}\times 100\right)\right] + \frac{1}{3}\left[\left(\frac{\Delta C}{C}\right)\times 100\right]$$

$$+\frac{1}{2}\left[\left(\frac{\Delta D}{D}\right)\times 100\right]$$

$$= 2\times 1 + 2 + \frac{1}{3}\times 3 + \frac{1}{2}\times 4$$

$$= 7\,\%$$

461. In a simple pendulum, experiment for determination of acceleration due to gravity (g), time taken for 20 oscillations is measured by using a watch of 1 second least count. The mean value of time taken comes out to be 30 s. The length of pendulum is measured by using a meter scale of least count 1 mm and the value obtained 55.0 cm. The percentage error in the determination of g is close to

(a) 0.7% (b) 6.8%
(c) 3.5% (d) 0.2%

JEE Main-08.04.2019, Shift-II

Ans. (b) : Given that,

Oscillation = 20

Least count = 1 second

Mean value of time taken = 30 second

$$T = \frac{30}{20} = 1.5\,\text{sec}$$

$$\Delta T = \frac{1}{20}\,\text{sec}$$

$$\frac{\Delta T}{T} = \frac{1/20}{30/20} = \frac{1}{30}$$

$l = 55$ cm , $\Delta l = 1$ mm $= 0.1$ cm

$$\frac{\Delta l}{l} = \frac{0.1}{55}$$

Time period of simple pendulum (T) = $2\pi\sqrt{\frac{l}{g}}$

$$g = \frac{4\pi^2 l}{T^2}$$

$$\frac{\Delta g}{g}\times 100 = \frac{\Delta l}{l}\times 100 + 2\frac{\Delta T}{T}\times 100$$

$$\frac{\Delta g}{g}\times 100 = \frac{0.1}{55}\times 100 + 2\left(\frac{1}{30}\times 100\right)$$

$$\frac{\Delta g}{g}\times 100 = 6.8\%$$

462. In the density measurement of a cube, the mass and edge length are measured as (10.00±0.10) kg and (0.10±0.01)m, respectively. The error in the measurement of density is

(a) 0.01 kg/m^3 (b) 0.10 kg/m^3
(c) 0.07 kg/m^3 (d) 0.31 kg/m^3

JEE Main-09.04.2019, Shift-I

@apna_pdf

Ans. (d) : Given,

$$\Delta m = 0.10, m = 10,$$
$$\Delta l = 0.041, l = 0.10$$
$$\therefore \quad \rho = \frac{m}{V}$$

$\{\because v = l^3$

$$V = l^3$$
$$\therefore \quad \rho = \frac{m}{l^3}$$
$$\therefore \quad \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta l}{l}$$
$$\frac{\Delta\rho}{\rho} = \frac{0.10}{10.00} + 3\times\frac{0.01}{0.10}$$
$$= \frac{1}{100} + \frac{30}{100}$$
$$\frac{\Delta\rho}{\rho} = \frac{31}{100} = 0.31\,kg/m^3$$

463. The sides of a rectangular plate are (9.0 ± 0.3) cm and (3.0 ± 0.1) cm. The area of the plate with error limits is

(a) $(27.0 \pm 0.1)cm^2$ (b) $(27.0 \pm 0.3)cm^2$
(c) $(27.0 \pm 1.8)cm^2$ (d) $(27.0 \pm 0.2)cm^2$

AP EAMCET-24.04.2019, Shift-II

Ans. (c) : Given that,

Length (l) = (9.0 ± 0.3)
Breadth (d) = (3.0 ± 0.1)
Area (A) = l × b = 9 × 3 = 27 cm^2

Percentage error of Area

$$\frac{\Delta A}{A} = \frac{\Delta l}{l} + \frac{\Delta b}{b}$$
$$\frac{\Delta A}{A} = \left(\frac{0.3}{9.0} + \frac{0.1}{3.0}\right) = \frac{1.8}{27.0}$$
$$\Delta A = \frac{1.8}{27.0}\times A$$
$$\Delta A = \frac{1.8}{27.0}\times A$$
$$\Delta A = \frac{1.8}{27.0}\times 27.0$$
$$\Delta A = 1.8$$

So, Area = $(27.0 \pm 1.8)cm^2$

464. The density of the material of a cube can be estimated by measuring its mass and the length of one of its sides. If the maximum error in the measurement of mass and length are 0.3% and 0.2% respectively, the maximum error in the estimation of the density of the cube is approximately.

(a) 1.1% (b) 0.5%
(c) 0.9% (d) 0.7%

WB JEE 2019

Ans. (c) : Given that,

Mass error (m) = 0.3%
Length error (l) = 0.2%

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$
$$\rho = \frac{M}{V} = \frac{M}{l^3}$$

taking log of both side

log ρ = log M + 3 log l

Differentiating both side

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta l}{l}$$

The percentage error

$$\frac{\Delta\rho}{\rho}\times 100 = \left[\frac{\Delta m}{m}\times 100\right] + 3\left[\frac{\Delta l}{l}\times 100\right]$$
$$\frac{\Delta\rho}{\rho}\times 100 = 0.3\% + (3\times 0.2)\%$$
$$\frac{\Delta\rho}{\rho}\times 100 = 0.3\% + 0.6\%$$
$$\frac{\Delta\rho}{\rho}\times 100 = 0.9\%$$

465. A current carrying conductor obeys Ohm's law (V = RI). If the current passing through the conductor is I = (5 ± 0.2) A and voltage developed is V = (60 ± 6) V, then find the percentage of error is resistance, R

(a) 18 (b) 6
(c) 14 (d) 2

TS-EAMCET-04.05.2019, Shift-2

Ans. (c) : Percentage error in resistance is given as–

$$\left(\frac{\Delta R}{R}\times 100\right)\% = \left(\frac{\Delta V}{V}\right)\times 100 + \left(\frac{\Delta I}{I}\right)\times 100$$

Where V = 60 v, ΔV = 6v
I = 5A, ΔI = 0.2A

$$\therefore \left(\frac{\Delta R}{R}\times 100\right)\% = \left(\frac{6}{60}\right)\times 100 + \left(\frac{0.2}{5}\times 100\right)$$
$$\left(\frac{\Delta R}{R}\times 100\right)\% = \left(\frac{600}{60}\right) + \left(\frac{20}{5}\right)$$
$$\left(\frac{\Delta R}{R}\times 100\right)\% = 10 + 4 = 14\%$$
$$\boxed{\left(\frac{\Delta R}{R}\times 100\right)\% = 14\%}$$

466. A quantity *z*, to be estimated has a dependency on the variables *a, b* and *c* as $z = ab^2c^{-2}$. The percentage of error in the measurement of *a, b* and *c* are respectively, 2.1%, 1.3% and 2.2%. The percentage of error in the measurement of *z* would then be

(a) 5.6% (b) 1.6%
(c) 1.0% (d) 9.1%

TS-EAMCET-04.05.2019, Shift-1

@apna_pdf

Ans. (d) : Given, $z = ab^2c^{-2}$

The percentage error in measurement of Z is given as–

$$\left(\frac{\Delta Z}{Z}\times 100\right)\% = \left(\frac{\Delta a}{a}\times 100\right)\% + 2\left(\frac{\Delta b}{b}\times 100\right)\% + 2\left(\frac{\Delta c}{c}\times 100\right)\%$$

$$\because \left(\frac{\Delta a}{a}\times 100\right)\% = 2.1\%,\quad \left(\frac{\Delta b}{b}\times 100\right)\% = 1.3\%,\quad \left(\frac{\Delta c}{c}\times 100\right)\% = 2.2\%$$

$$\therefore\ \left(\frac{\Delta Z}{Z}\times 100\right)\% = (2.1\%) + 2\times(1.3\%) + 2\times(2.2\%)$$

$$\left(\frac{\Delta Z}{Z}\times 100\right)\% = 2.1\% + 2.6\% + 4.4\%$$

$$\boxed{\left(\frac{\Delta Z}{Z}\times 100\right)\% = 9.1\%}$$

467. If 1% and 2% are the errors in the measurement of mass and density of a cube respectively, then the error in the measurement of length is

(a) 1% (b) 3%

(c) 2% (d) 4%

AP EAMCET (22.04.2019) Shift-I

Ans. (a) : Volume of cube, $V = a^3$

Where, a = side of cube

Density of cube is given as $\rho = \dfrac{m}{V}$

$$\because V = a^3$$

$$\therefore \rho = \frac{m}{a^3}$$

$$a^3 = \frac{m}{\rho}$$

$$a = \left(\frac{m}{\rho}\right)^{1/3}$$

So, percentage error in measurement of length of a cube is given as–

$$\left(\frac{\Delta a}{a}\times 100\right)\% = \frac{1}{3}\left[\left(\frac{\Delta m}{m}\times 100\right)\% + \left(\frac{\Delta \rho}{\rho}\times 100\right)\%\right]$$

$$\because \left(\frac{\Delta m}{m}\times 100\right)\% = 1\%,\quad \left(\frac{\Delta \rho}{\rho}\times 100\right)\% = 2\%$$

$$\therefore \left(\frac{\Delta a}{a}\times 100\right)\% = \frac{1}{3}[1\% + 2\%]$$

$$\left(\frac{\Delta a}{a}\times 100\right)\% = \frac{1}{3}\times 3\% = 1\%$$

$$\boxed{\left(\frac{\Delta a}{a}\times 100\right)\% = 1\%}$$

468. Choose the incorrect statement out of the following?

(a) Every measurement by any measuring instrument has some error.

(b) Every calculated physical quantity that is based on measured values has some error.

(c) A measurement can have more accuracy but less precision and vice versa.

(d) The percentage error is different from relative error.

COMEDK 2019

Ans. (d):

$$\text{(i) Percentage error} = \frac{\text{Measured value} - \text{real value}}{\text{real value}}$$

$$\text{(ii) Relative error} = \frac{\text{Measured value} - \text{real value}}{\text{real value}}$$

By above formulas, it is clear that there is no difference in percentage error & relative error.

469. Calculate the percentage error for five observations: 80.0, 80.5, 81.0, 81.5, 82

(a) 0.74% (b) 1.74%

(c) 0.38% (d) 1.38%

AIIMS-26.05.2019(E) Shift-2

Ans. (a) :

$$\text{Mean} = \frac{80 + 80.5 + 81 + 81.5 + 82}{5}$$

$$M = 81$$

$$\Delta M_1 = |80-81| = 1$$

$$\Delta M_2 = |80.5-81| = 0.5$$

$$\Delta M_3 = |81-81| = 0$$

$$\Delta M_4 = |81.5-81| = 0.5$$

$$\Delta M_5 = |82-81| = 1$$

$$\text{Mean error} = \frac{1 + 0.5 + 0 + 0.5 + 1}{5}$$

$$= 0.6$$

$$\%\ \text{errors} = \frac{0.6}{81}\times 100 = 0.74\%$$

470. The velocity of projection of a body is increased by 2%. Other factors remaining unchanged, what will be the percentage change in the maximum height attained?

(a) 1% (b) 2%

(c) 4% (d) 8%

AIIMS-25.05.2019(E) Shift-2

Ans. (c) : Height of projection

$$H = \frac{u^2\sin^2\theta}{2g} \Rightarrow H \propto u^2,\ \left(\frac{\sin^2\theta}{2g}\right) = \text{constant}$$

taking log and differentiating

log H = 2 log 4

$$\frac{\Delta H}{H} = 2\frac{\Delta u}{u}$$

$$\frac{\Delta H}{H} = 2\frac{\Delta u}{u} \Rightarrow \frac{\Delta H}{H}\times 100 = 2\frac{\Delta u}{u}\times 100$$

$$= 2(2\%) = 4\%$$

471. A wire has a mass (0.1 ± 0.001)g radius (0.5 ± 0.005) mm and length (10 ± 0.1)cm. The maximum percentage error in the measurement of its density is.

(a) 1% (b) 2%

(c) 3% (d) 4%

UPSEE 2019

@apna_pdf

Ans. (d) : Density $D = \dfrac{\text{mass(m)}}{\text{volume(v)}}$

$$\log D = \log m + \log v \qquad \{\because \text{ for maximum}\}$$

$$\frac{\Delta D}{D} = \frac{\Delta M}{M} = \frac{\Delta V}{V}$$

$$\frac{\Delta D}{D} \times 100 = \frac{\Delta M}{M} \times 100 = \frac{\Delta V}{V} \times 100$$

$$= \frac{0.001}{0.1} \times 100 + \left(2 \times \frac{0.005}{0.5} + \frac{0.1}{10}\right) \times 100$$

$$= 0.01 + 0.02 + 0.01 \times 100$$

$$= 0.04 \times 100 = 4\%$$

472. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of −0.004cm, the correct diameter of the ball is

(a) 0.053 cm (b) 0.525 cm

(c) 0.521 cm (d) 0.529 cm

[NEET 2018]

Ans. (c) : Given that,

Main scale reading (MSR) = 5 mm = 0.5 cm

Circular scale division (CSD) = 25

least count = 0.001 cm

zero error = – 0.004 cm

Thus,

Diameter = calculated diameter value – zero error

= MSR + CSD × LC – zero error

= 0.5 + 25 × 0.001 – (– 0.004)

= 0.5 + 0.025 + 0.004

= 0.529 cm

473. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5%and 1%, the maximum error in determining the density is

(a) 2.5% (b) 3.5%

(c) 4.5% (d) 6%

JEE Main 2018

Ans. (c) : Given that,

% Error in mass $\left(\dfrac{\Delta m}{m} \times 100\right) = 1.5\ \%$

% Error in length $\left(\dfrac{\Delta l}{l} \times 100\right) = 1\%$

Density $= \dfrac{m}{v}$

Volume of cube $= l^3$

So,

Relative Error in density $(\rho) = \dfrac{m}{l^3}$

$$\frac{\Delta \rho}{\rho} \times 100 = \left(\frac{\Delta m}{m} + 3\frac{\Delta l}{l}\right) \times 100$$

$$\frac{\Delta \rho}{\rho} \times 100 = 1.5\% + 3 \times 1\%$$

$$\frac{\Delta \rho}{\rho} \times 100 = 1.5\% + 3\%$$

$$\frac{\Delta \rho}{\rho} \times 100 = 4.5\%$$

474. A wooden cubical block of mass, m = 20 kg is measured within an error of 10 g. Its side length, *l* = 100 cm is measured within an error of 1mm. Then, the relative error in the measurement of its density is

(a) 1.8×10^{-2} (b) 2.6×10^{-2}

(c) 3.5×10^{-3} (d) 4.8×10^{-3}

TS-EAMCET-05.05.2018, Shift-2

Ans. (c) : Relative error in density of wooden cubical block is given as–

$$\boxed{\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + \frac{3\Delta l}{l}} \quad \text{........(1)}$$

Here, $\Delta m = 10\,\text{gm} = 10 \times 10^{-3}\,\text{kg}$

$\Delta l = 1\,\text{mm} = 1 \times 10^{-1}\,\text{cm} = 0.1\,\text{cm}$

$m = 20$ kg, $l = 100$cm

Putting the above value in equation number (1)

$$\frac{\Delta \rho}{\rho} = \frac{10 \times 10^{-3}}{20} + \frac{3 \times 0.1}{100}$$

$$\frac{\Delta \rho}{\rho} = \frac{1 \times 10^{-3}}{2} + \frac{0.3}{100} = 0.5 \times 10^{-3} + 3 \times 10^{-3}$$

$$\boxed{\frac{\Delta \rho}{\rho} = 3.5 \times 10^{-3}}$$

475. The resistance $R = \dfrac{V}{I}$, where $V = (100 \pm 5)V$ and $I = (10 \pm 0.2)A$. The percentage error in R is :

(a) 5.2% (b) 4.8%

(c) 7% (d) 3%

Karnataka CET-2018

Ans. (c) : Given, $R = \dfrac{V}{I}$

$$\frac{\Delta R}{R} = \pm\left(\frac{\Delta V}{V} + \frac{\Delta I}{I}\right)$$

$$\left(\frac{\Delta R}{R} \times 100\right) = \pm\left(\frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100\right)$$

$$= \pm\left(\frac{5}{100} \times 100 + \frac{0.2}{10} \times 100\right)$$

$$= \pm(5 + 2) = \pm 7\%$$

476. The length of a body is measured as 3.51 m. If the accuracy is 0.01 m, then the percentage error in the measurement is ____________.

(a) 351% (b) 1%

(c) 0.28% (d) 0.03%

SRM JEE-2018

@apna_pdf

Ans. (c) : Given that,

Measured length of the body (l) = 3.51 m

Accuracy $(\Delta l) = 0.01$ m

$$\% \text{ error } = \frac{\Delta l}{l} = \frac{0.01}{3.51} \times 100$$

$= 0.2849\% \approx 0.28\%$

477. R = 65± 1Ω L, l = 5 ± 0.1 mm and d = 10 ± 0.5 mm. Find error I calculation of resistivity.

(a) 21% (b) 13%

(c) 16% (d) 41%

JIPMER-2018

Ans. (b) : Given that,

R = 65 ± 1 Ω, l = 5 ±0.1 mm, d = 10 ± 0.5

Since we know that

$$R = \rho \frac{l}{A}$$

$$\rho = \frac{RA}{l}$$

$$\rho = R\frac{\pi d^2}{4l}$$

So, error in resistivity, $\frac{\Delta\rho}{\rho} = \frac{\Delta R}{R} \pm \frac{2\Delta d}{d} \pm \frac{\Delta l}{l}$

$$\frac{\Delta\rho}{\rho} = \frac{1}{65} + \frac{2\times(0.5)}{10} + \frac{(0.1)}{5}$$

$$\frac{\Delta\rho}{\rho} = 0.015 + 0.1 + 0.02$$

$$\frac{\Delta\rho}{\rho} = 0.015 + 0.1 + 0.02$$

$$\frac{\Delta\rho}{\rho} = 0.135$$

$$\frac{\Delta\rho}{\rho} \times 100\% = 0.135 \times 100$$

$$\boxed{\frac{\Delta\rho}{\rho} \times 100\% = 13.5\%}$$

478. A physical quantity Q is related to four independent observables α, β, c and d as $Q = \frac{\alpha^3\beta^2}{\sqrt{cd}}$ The percentage error of measurement is α, β,c and d respectively are 1% 3% 4% and 2% The percentage error in the quantity Q is then

(a) 5% (b) 12%

(c) 13% (d) 24%

TS EAMCET(Medical)-2017

Ans. (b) : Given,

$$Q = \frac{\alpha^3\beta^2}{\sqrt{cd}}$$

Percentage change in Q

$$\frac{\Delta Q}{Q} \times 100 = 3\left(\frac{\Delta\alpha}{\alpha} \times 100\right) + 2\left(\frac{\Delta\beta}{\beta} \times 100\right) + \frac{1}{2}\left(\frac{\Delta c}{c} \times 100\right) + \frac{1}{2}\left(\frac{\Delta d}{d} \times 100\right)$$

$= 3\ (1\%) + 2(3\%) + \frac{1}{2}(4\%) + \frac{1}{2}(2\%)$

$= 3\% + 6\% + 2\% + 1\%$

$= 12\%$

479. A force $\vec{F}$ is applied on a square plate of length L. If the percentage error in the determination of L is 3% and in F is 4% the permissible error in the calculation of pressure is

(a) 13% (b) 10%

(c) 7% (d) 12%

TS EAMCET (Engg.)-2017

Ans. (b) : Given,

Percentage error in length

$$(L) = \frac{\Delta L}{L} \times 100\% = 3\%$$

Percentage error in force $(F) = \frac{\Delta F}{F} \times 100\% = 4\%$

Pressure $(P) = \frac{\text{Force}(F)}{\text{Area}(A)} = \frac{F}{A}$

$$P = \frac{F}{L^2} \qquad (\because A = L^2)$$

Permissible error in pressure

$$\frac{\Delta P}{P} \times 100\% = \frac{\Delta F}{F} \times 100\% + 2\frac{\Delta L}{L} \times 100\%$$

$$\frac{\Delta P}{P} \times 100\% = 4\% + 2 \times 3\%$$

$$\frac{\Delta P}{P} \times 100\% = 10\%$$

480. The following observations were taken for determining surface tension T of water by capillary method, Diameter of capillary, d =1.25 ×10^{-2} m, Rise of water, h =1.45 ×10^{-2} m. Using g =9.80m/s^2 and the simplified relation $T = \frac{rhg}{2} \times 10^3$ N/m, the possible error in surface tension is closest to

(a) 1.5% (b) 2.4%

(c) 10% (d) 0.15%

JEE Main 2017

Ans. (a) : Given,

Diameter of capillary = 1.25 × 10^{-2}m

Rise of water = 1.45 × 10^{-2}m

$$T = \frac{rhg}{2} \times 10^3 \text{ N/m} \qquad \Delta r = 0.01\text{m}$$

$$\Delta h = 0.01\text{m}$$

taking log of both side

log T = log r + log h

Differentiating both side

@apna_pdf

$$\frac{\Delta T}{T}=\frac{\Delta r}{r}+\frac{\Delta h}{h}$$

$$\frac{\Delta T}{T}=\frac{0.01}{1.25}+\frac{0.01}{1.45}$$

$$\frac{\Delta T}{T}\times 100=\left(\frac{1}{125}+\frac{1}{145}\right)\times 100$$

$$\frac{\Delta T}{T}\times 100=0.8+0.69$$

$$\approx 1.5\%$$

481. If a copper wire is stretched to make its radius decreased by 0.1%, then the percentage increase in resistance is approximately?

(a) 0.1% (b) 0.2%
(c) 0.5% (d) 0.4%

Assam CEE-2017

Ans. (d): Given, $\frac{\Delta r}{r}=0.1\%$

When a wire is stretched its volume remains constant

$$\mathbf{R}=\rho\frac{L}{A}$$

$$=\left(\rho\frac{L}{A}\right)\times\frac{A}{A}$$

$$=\rho\frac{V}{A^2}$$

$$=\rho\frac{V}{\left(\pi^2 r^4\right)}$$

From above-

$$R\propto\frac{1}{r^4}$$

$$\frac{\Delta R}{R}=4\times\frac{\Delta r}{r}$$

$$\frac{\Delta R}{R}\times 100=4\times\left(\frac{\Delta r}{r}\times 100\right)$$

$$=4\times 0.1$$

$$=0.4\%$$

Resistance of wire is increased by 0.4 percent.

482. In a measurement, random error

(a) can be decreased by increasing the number of readings and averaging them
(b) can be decreased by changing the person who takes the reading
(c) can be decreased by using new instrument
(d) can be decreased by using a different method in taking the reading
(e) cannot be decreased

Kerala CEE - 2017

Ans. (a) : In a measurement, the random error can be minimized by increasing the number of readings and averaging them.

483. Assertion: In the measurement of physical quantities direct and indirect methods are used.

Reason: The accuracy and precision of measuring instruments along with errors in measurements should be taken into account, while expressing the result.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2017

Ans. (a) : Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

484. If the absolute errors in two physical quantities A and B are a and b respectively, then the absolute error in the value of A – B is

(a) a – b (b) b – a
(c) a = b (d) a + b

AP EAMCET(Medical)-2014

Ans. (d) : Absolute error in the given value,

$X = A - B$
$\Delta A = a$
$\Delta B = b$
$\Delta X = \Delta A + \Delta B$
$\Delta X = a + b$

Where a and b are absolute errors in the quantity A and B respectively.

485. While measuring acceleration due to gravity by a simple pendulum, a student makes a positive error of 2% in the length of the pendulum and a positive error of 1% in the value of time period, this actual percentage error in the measurement of the value of g will be

(a) 5% (b) 4%
(c) 3% (d) 0%

AP EMCET(Medical)-2011

Ans. (d) : Given that

$$\frac{\Delta l}{l}\times 100=+2\%$$

$$\frac{\Delta T}{T}\times 100=+1\%$$

$$g=\frac{4\pi^2 l}{T^2}$$

$$\frac{\Delta g}{g}\times 100=\frac{\Delta l}{l}\times 100+(-2)\frac{\Delta T}{T}\times 100$$

$$\frac{\Delta g}{g}\times 100=2\%+(-2)\times(1)\%$$

$$\frac{\Delta g}{g}\times 100=2\%-2\%$$

$$\frac{\Delta g}{g}\times 100=0\%$$

@apna_pdf

486. Dimensional formula of a physical quantity X is $[M^{-1}L^3T^{-2}]$ the errors is measuring the quantities M,L and T respectively are 2%,3% and 4%, The maximum percentage of error that occurs in measuring the quantity X is:

(a) 9 (b) 10
(c) 14 (d) 19

AP EAMCET(Medical)-2002

Ans. (d) : Given that,

$$X = [M^{-1}L^3T^{-2}]$$

$$\frac{\Delta X}{X} \times 100 = \frac{\Delta M}{M}\times 100 + 3\frac{\Delta L}{L}\times 100 + 2\frac{\Delta T}{T}\times 100$$

$$= 2\% + 3 \times 3\% + 2 \times 4\%$$

$$= 2\% + 9\% + 8\%$$

$$= 19\%$$

The maximum percentage of error occur in measuring is 19%.

487. A clock with an iron pendulum keeps correct time at 15^0C. If room temperature rises to 20^0C, the error in seconds per day will be : (coefficient of linear expansion of iron is $00.000012/^0C$)

(a) 2.5 s (b) 2.6 s
(c) 2.4 s (d) 2.2 s

AP EAMCET(Medical)-1997

Ans. (b) : Given that,

$t_1 = 15°C$

$t_2 = 20°C$

$\alpha = 00.000012/^0C = 12 \times 10^{-6}/°C$

Loss or gain time per day

$$= \frac{1}{2} \times \alpha\Delta T \times 24 \times 60 \times 60$$

$$= \frac{1}{2} \times 12 \times 10^{-6} \times 5 \times 24 \times 60 \times 60$$

$$= 2.592$$

$$\approx 2.6 \text{ sec}$$

488. On heating, the length of the side of cube changes by 2%. The volume of the cube changes by

(a) 1% (b) 6%
(c) 0.5% (d) 3%

EAMCET-1992

Ans. (b) : Given that,

Change in length $\frac{\Delta L}{L} = 2\%$

We know that,

Vol. of cube, $V = L^3$

Change in volume $= \frac{3\Delta L}{L}$

$$= 3 \times 2\%$$

$$= 6\%$$

Hence, volume of cube changed by 6%.

489. In an experiment of simple pendulum, the errors in the measurement of length of the pendulum (L) and time period (T) are 3% and 2% respectively. The maximum percentage error in the value of $\frac{L}{T^2}$ is

(a) 5% (b) 7%
(c) 8% (d) 1%

EAMCET-2001

Ans. (b) : Given that,

Error in the measurement of length, $\frac{\Delta L}{L} = 3\%$

Error in the measurement of time, $\frac{\Delta T}{T} = 2\%$

Let $\frac{L}{T^2} = x$

So, the fractional error in the measurement of x

$$\frac{\Delta x}{x}\times 100 = \frac{\Delta L}{L}\times 100 + \frac{2\Delta T}{T}\times 100$$

$$= 3 + 2\ (2) = 3 + 4 = 7\%$$

Hence, the maximum percentage error in the value of $\frac{L}{T^2}$ is 7%.

490. In the measurement of a physical quantity X = $\frac{A^2B}{C^{1/3}D^3}$. The percentage errors introduced in the measurements of the quantities A, B, C and D are 2%, 2%, 4% and 5% respectively. Then, the minimum amount of percentage error in the measurements of X is contributed by

(a) A (b) B (c) C (d) D

EAMCET-2002

Ans. (c) : Given that, $X = \frac{A^2B}{C^{1/3}D^3}$

So fractional error in the measurement of X is

$$\frac{\Delta x}{x}\times 100 = \frac{2\Delta A}{A}\times 100 + \frac{\Delta B}{B}\times 100 + \frac{1}{3}\frac{\Delta C}{C}\times 100 + \frac{3\Delta D}{D}\times 100$$

$$= (2\times 2) + 2 + \left(\frac{1}{3}\times 4\right) + (3\times 5)$$

$$= 4 + 2 + \left(\frac{1}{3}\times 4\right) + 15$$

So, $\left(\frac{1}{3}\times 4\right)$ is contribute minimum error among them

Hence, minimum error is contributed by C.

491. In an experiment four quantities a, b, c and d are measured with percentage error 1%, 2%. 3% and 4% respectively. A quantity 'P' is calculated as $P = \frac{a^3b^2}{cd}$. Then the percentage error in 'P' is

(a) 14% (b) 10%
(c) 7% (d) 4%

AP EAMCET-28.04.2017, Shift-II
NEET- 2013

@apna_pdf

Ans. (a) : Given that,

Percentage change in, a $\left(\frac{\Delta a}{a}\times 100\right)=1\%$

Percentage change in, b $\left(\frac{\Delta b}{b}\times 100\right)=2\%$

Percentage change in, c $\left(\frac{\Delta c}{c}\times 100\right)=3\%$

Percentage change in, d $\left(\frac{\Delta d}{d}\times 100\right)=4\%$

and $P=\frac{a^3b^2}{cd}$

Percentage change in P = ?

$$\frac{\Delta P}{P}\times 100=3\left(\frac{\Delta a}{a}\times 100\right)+2\left(\frac{\Delta b}{b}\times 100\right)+\left(\frac{\Delta c}{c}\times 100\right)+\left(\frac{\Delta d}{d}\times 100\right)$$

= 3 × 1% + 2 × 2% + 1 × 3% + 1 × 4%

= 3% + 4% + 3% + 4%

$$\frac{\Delta P}{P}\times 100=14\%$$

Percentage change in P = 14%

492. The percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in kinetic energy obtained by measuring mass and speed, will be

(a) 12% (b) 10%

(c) 8% (d) 2%

[AIPMT 1995]

Ans. (c) : Given that,

% error in mass (m) = 2%

% error in speed (v) = 3%

$\because$ $\text{K.E.}=\frac{1}{2}mv^2$

taking log of both side

logE = 10g m + 2 log v

Differentiating of both side

$$\frac{\Delta E}{E}=\frac{\Delta M}{M}+\frac{\Delta V}{V}$$

$$=\left(\frac{\Delta m}{m}\times 100\right)+2\left(\frac{\Delta v}{v}\times 100\right)$$

= 1×2% + 2 × 3%

= 2% + 6%

= 8%

493. The density of a cube is measured by measuring its mass and length of its sides. If the maximum error in the measurement of mass and length are 4% and 3% respectively, the maximum error in the measurement of density will be

(a) 7% (b) 9%

(c) 12% (d) 13%

[AIPMT 1996]

Ans. (d) : Given that,

% error in mass = 4%

% error in length = 3%

$\because$ Density $D=\frac{\text{mass}}{\text{volume}}=\frac{m}{L^3}$

$$\therefore\quad \frac{\Delta D}{D}\times 100=\left(\frac{\Delta m}{m}\times 100\right)+3\left(\frac{\Delta L}{L}\times 100\right)$$

= 1 × 4% + 3 × 3%

= 4% + 9%

max. error in measurement of density = 13%

494. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is

(a) 6% (b) zero

(c) 1% (d) 3%

AIEEE 2012

Ans. (a) : Given that,

% error in Voltage (V) = 3%

% error in current (I) = 3%

$\because$ $R=\frac{V}{I}$

$$\frac{\Delta R}{R}\times 100=\frac{\Delta V}{V}\times 100+\frac{\Delta I}{I}\times 100$$

$$\frac{\Delta R}{R}\times 100=3\%+3\%$$

max. error in resistance of wire = 6%

495. The current voltage relation of diode is given by $I=(e^{1000V/T}-1)$ mA, where the applied voltage V is in volt and the temperature T is in kelvin. If a student makes an error measuring ± 0.01V while measuring the current of 5 mA at 300K, what will be the error in the value of current in mA?

(a) 0.2 mA (b) 0.02 mA

(c) 0.5 mA (d) 0.05 mA

JEE Main 2013

Ans. (a) : Given that,

$I=(e^{1000V/T}-1)$ mA ---------(1)

$e^{1000V/T}=I+1=5+1=6$ mA

and I = 5 mA,T = 300 K

Voltage error $=\frac{\Delta V}{V}=\pm 0.01$ V

Differentiating 1st equation, with respect to V

$$\frac{dI}{dV}=e^{1000V/T}\times\frac{1000}{T}$$

$$dI=e^{1000V/T}\times\frac{1000}{T}dV$$

$$dI=\frac{1000}{T}(e^{1000V/T})dV$$

@apna_pdf

$$dI = \frac{1000}{T}(I+1)\,dV \qquad [\because e^{1000V/T} = I + 1]$$

$$dI = \frac{1000}{300}(5+1) \times 0.01$$

$$dI = 0.2 \text{ mA}$$

496. The length of a pendulum is measured as 1.01 m and time for 30 oscillations is measured as one minute 3 s. Error length is 0.01 m and error in time is 3 s. The percentage error in the measurement of acceleration due to gravity is

(a) 1 (b) 5

(c) 10 (d) 15

AP EAMCET -2012

Ans. (c) : Given data,

T = 1 min 3 sec

= 60 + 3

= 63 sec

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T^2 = 4\pi^2\frac{l}{g} \Rightarrow g = \frac{4\pi^2 l}{T^2}$$

Error analysis,

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$$

$$\frac{\Delta g}{g} = \frac{0.01}{1.01} + 2\times\frac{3}{63}$$

$$\frac{\Delta g}{g} = 0.0099 + 0.095$$

$$\frac{\Delta g}{g}\times 100 = [0.0099 + 0.095]\times 100$$

$$= 0.1042\times 100$$

$$= 10.4\% \approx 10\%$$

497. The pressure on a circular plate is measured by measuring the force on the plate and the radius of the plate. If the errors in measurement of the force and the radius are 5% and 3% respectively, the percentage of error in the measurement of pressure is

(a) 8 (b) 14

(c) 11 (d) 12

AP EAMCET -2015

Ans. (c) : Given that,

Force = 5%

Radius = 3%

$$P = \frac{F}{A} = \frac{F}{\pi R^2}$$

$$\frac{\Delta P}{P}\times 100 = \frac{\Delta F}{F}\times 100 + 2\frac{\Delta R}{R}\times 100$$

$$\frac{\Delta P}{P}\times 100 = 5 + 2\times 3$$

$$\frac{\Delta P}{P}\times 100 = 11\%$$

498. A public park, in the form of a square, has an area of $(100 \pm 0.2)\text{m}^2$. The side of park is

(a) (10 ± 0.01)m (b) (10 ± 0.1)m

(c) (10.0 ± 0.1)m (d) (10.0 ± 0.2)m

UP CPMT-2014

Ans. (a) : Area = $(100\pm 0.2)\text{m}^2$

So,

$100 = l^2$

$10 \text{ m} = l$ (length)

Now,

$$\frac{\Delta A}{A} = \frac{2\Delta l}{l}$$

$$\frac{0.2}{100} = 2\times\frac{\Delta l}{10}$$

$\Delta l = 0.01$ m

So, length = (10 ± 0.01)m

499. If the error in the measurement of momentum of a particle is (+100%), then the error in the measurement of kinetic energy is

(a) 25% (b) 200%

(c) 300% (d) 400%

UP CPMT-2014

Ans. (c) : We know that

Momentum (p) = mv

Kinetic energy (KE) = $\frac{1}{2}mv^2$

Then,

$$KE = \frac{p^2}{2m}$$

Given, $p_i = p$

$$p_f = p + \frac{p\times 100}{100} = 2p$$

Error,

$$\frac{KE_f - KE_i}{KE_i}\times 100 = \frac{p_f^2 - p_i^2}{p_i^2}\times 100$$

$$\text{Error} = \frac{(2p)^2 - p^2}{p^2}\times 100$$

$= 3\times 100$

$= 300\%$

500. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increases in the apparent frequency?

(a) Zero (b) 0.5%

(c) 5% (d) 20%

UP CPMT-2008

Ans. (d) : When the observer is moving towards a stationary source.

Apparent frequency, $V' = V\left[\frac{V+V_0}{V}\right]$

$$V' = V\left[\frac{V+\frac{V}{5}}{V}\right]$$

@apna_pdf

Or, $V' = \frac{6}{5}V$

$\therefore$ Percentage increase in frequency is

$$= \frac{V' - V}{V} \times 100$$

$$= \frac{\frac{6}{5}V - V}{V} \times 100$$

$$= \frac{\frac{1}{5}V}{V} \times 100$$

$\therefore$ % change = 20%

501. The side of a cubical block when measured with a vernier calipers is 2.50 cm. The vernier constant is 0.01 cm. The maximum possible error in the area of the side of the block is

(a) ± 0.01 cm^2 (b) ± 0.02 cm^2

(c) ± 0.05 cm^2 (d) ± 0.10 cm^2

SRMJEE - 2009

Ans. (c) : Given,

$l = 2.50$ cm

Vernier constant $\Delta l = 0.01$ cm

$\therefore$ Maximum possible error in measurement of Δl = 0.01 cm

$\Rightarrow$ Area = l^2

$$\frac{\Delta A}{A} = \frac{2\Delta l}{l}$$

$$\Rightarrow \Delta A = \frac{2(0.01)}{(2.50)} \times (2.50)^2 = 0.05 \text{cm}^2$$

Maximum possible error in measurement of area= ± 0.05cm^2

502. The percentage errors in the measurement of mass and speed are 1% and 2% respectively. What is the percentage error in the kinetic energy

(a) 5% (b) 2.5%

(c) 3% (d) 1.5%

SRMJEE - 2010

Ans. (a) : Given that,

$$\frac{\Delta m}{m} \times 100 = 1\%, \frac{\Delta v}{v} \times 100 = 2\%$$

$$K = \frac{1}{2}mv^2$$

taking log of both side

log k = log m + 2 log v

Differentiating both side

$$\therefore \frac{\Delta K}{K} \times 100 = \left(\frac{\Delta m}{m} + \frac{2\Delta v}{v}\right) \times 100$$

% error in K = (% error in m) + 2 × (% error in v)

= 1% + 2 × 2% = 5%

503. A Force F is applied on a square plate side L. If the percentage error in the determination of L is 2% and that in F is 4%, what is the permissible error in pressure

(a) 2% (b) 4%

(c) 6% (d) 8%

SRMJEE - 2013

Ans. (d) : Given,

$$\frac{\Delta L}{L} \times 100 = 2\% \text{ and } \frac{\Delta F}{F} \times 100 = 4\%$$

$$P = \frac{F}{A} = \frac{F}{L^2}$$

$$\frac{\Delta P}{P} = \frac{\Delta F}{F} + \frac{2\Delta L}{L}$$

% error in pressure

$$\left(\frac{\Delta P}{P} \times 100\right) = \left(\frac{\Delta F}{F} \times 100\right) + 2\left(\frac{\Delta L}{L} \times 100\right)$$

$$= 4\% + 2 \times 2\%$$

$$\frac{\Delta P}{P} \times 100 = 8\%$$

504. If the error in the measurement of radius of a sphere is 1% the error in the measurement of volume will be

(a) 1.1% (b) 3%

(c) 5% (d) 8%

SRMJEE - 2016

Ans. (b) : Given, $\frac{\Delta R}{R} = 1\%$

We know,

$$V = \frac{4}{3}\pi R^3$$

$$\frac{\Delta V}{V} = \frac{3\Delta R}{R}$$

$$\frac{\Delta V}{V} \times 100 = 3\frac{\Delta R}{R} \times 100$$

$$\frac{\Delta V}{V} \times 100 = 3\%$$

505. Two parameters a and c are measured experimentally and used to determine a quantity V given by $V = \frac{\sqrt{3}}{2}a^2c$. If the percentage errors in the measurement of a and c are respectively 1 and 2, the percentage error in the measurement of V is

(a) 3 (b) 5

(c) 1 (d) 4

Assam CEE-2016

@apna_pdf

Ans. (d) : Given,

$$\%\text{error in a} = \left(\frac{\Delta a}{a}\times 100\right) = 1\%$$

$$\%\text{error in c} = \left(\frac{\Delta c}{c}\times 100\right) = 2\%$$

$$V = \frac{\sqrt{3}}{2}a^2c$$

tanking log of both side

logv = 2 log a + log c

Differentiating both side

$$\frac{\Delta v}{v} = 2\frac{\Delta a}{a} + \frac{\Delta c}{c}$$

$$\left(\frac{\Delta v}{v}\times 100\right) = 2\left(\frac{\Delta a}{a}\times 100\right) + \left(\frac{\Delta c}{c}\times 100\right)$$

$$= 2\times 1 + 2$$

$$= 4\%$$

506. The percentage errors of the measurements of two physical quantities A and B are given by U_A and U_B ($U_A > U_B$). If the percentage errors of the measurements of A^2, B^2, AB are denoted by U_{A^2}, U_{B^2}, U_{AB} respectively, then

(a) $U_{AB} > U_{A^2} > U_{B^2}$
(b) $U_{A^2} > U_{AB} > U_{B^2}$
(c) $U_{B^2} > U_{AB} > U_{A^2}$
(d) $U_{A^2} = U_{AB} = U_{B^2}$

Assam CEE-2016

Ans. (b) :

$$U_A = \left(\frac{\Delta A}{A}\times 100\right)$$

$$U_B = \left(\frac{\Delta B}{B}\times 100\right)$$

$$U_{A^2} = 2\left(\frac{\Delta A}{A}\times 100\right)$$

$$U_{B^2} = 2\left(\frac{\Delta B}{B}\times 100\right)$$

$$U_{AB} = \left(\frac{\Delta A}{A}\times 100\right) + \left(\frac{\Delta B}{B}\times 100\right)$$

from upper eqn

$U_{A^2} > U_{AB}$........(i)

$U_{AB} > U_{B^2}$........(ii)

from eqn (i) and (ii)

$$U_{A^2} > U_{AB} > U_{B^2}$$

507. The poison's ratio of a material is 0.4. If a force is applied to a wire of this material, there is a decrease of cross-sectional area by 2%. The percentage increase in its length is

(a) 3%
(b) 2.5%
(c) 1%
(d) 0.5%

Assam CEE-2014

Ans. (b) : Given, Poison's ratio (v) = 0.4

$$v = 0.4,\ \Delta A\% = -2\%$$

$$\frac{\Delta A}{A}\times 100 = -2\%$$

$$A = \pi r^2$$

$$\frac{\Delta A}{A}\times 100 = 2\left(\frac{\Delta r}{r}\right)\times 100$$

$$2\times\frac{\Delta r}{r}\times 100 = -2$$

$$-\frac{\Delta r}{r} = \frac{1}{100}$$

Then,

$$\frac{\Delta l}{l} = \frac{\frac{\Delta r}{r}}{v}$$

$$\frac{\Delta l}{l}\times 100 = \frac{\frac{1}{100}}{0.4}\times 100$$

$$\text{Percentage change in length} = \frac{1\times 100}{0.4\times 100}$$

$$= \frac{10}{4} = 2.5\%$$

508. The velocity of a transverse wave in a string is directly proportional to $\sqrt{T}$ and inversely proportional to $\sqrt{\mu}$. In a measurement, the mass applied at the end of string is 3.0 gm, length of string is 1 m and mass of string is 5 gm. If possible error in measuring mass is 0.1 gm and that of length is 1 mm, the parentage error in measurement of velocity is

(a) 4.5%
(b) 2.7%
(c) 2.1%
(d) 3.7%

AMU-2016

Ans. (b): Given,

m = 3gm

l = 1m

according to question

$$v \propto \sqrt{\frac{T}{\mu}} = k\sqrt{\frac{T}{\mu}}$$

$$\mu = \frac{M}{L} \text{ and } T = m'g$$

$$v = K\sqrt{\frac{TL}{M}} = K\sqrt{\frac{m'gL}{M}}$$

$$\frac{\Delta v}{v} = \frac{1}{2}\times\frac{\Delta m'}{m'} + \frac{1}{2}\times\frac{\Delta L}{L} + \frac{1}{2}\times\frac{\Delta M}{M}$$

$$= \frac{1}{2}\times\frac{0.1}{5} + \frac{1}{2}\times\frac{1\times 10^{-3}}{1} + \frac{1}{2}\times\frac{0.1}{3}$$

$$= 0.01 + 0.0005 + 0.016$$

$$= 0.0271$$

$$\frac{\Delta v}{v}\times 100 = 2.7\%$$

@apna_pdf

509. A physical quantity Q is related to four observables x, y, z ad t by the relation

$$Q = \frac{x^{2/5}z^3}{y\sqrt{t}}$$

The percentage errors of measurement in x, y, z, and t are 2.5%, 2%, 0.5% and 1% respectively. The percentage error in Q will be

(a) 5% (b) 4.5%

(c) 8% (d) 7.75%

AMU-2006

Ans. (a) : Given,

$$\frac{\Delta x}{x} = 2.5\%,\quad \frac{\Delta y}{y} = 2\%,\quad \frac{\Delta z}{z} = 0.5\% \text{ and}$$

$$\frac{\Delta t}{t} = 1\%$$

Given, $Q = \frac{x^{\frac{2}{5}}z^3}{y\sqrt{t}}$

The percentage error in Q in given by,

$$\frac{\Delta Q}{Q}\times 100 = \frac{2}{5}\left(\frac{\Delta x}{x}\times 100\right) + 3\left(\frac{\Delta Z}{Z}\times 100\right)$$

$$+\left(\frac{\Delta y}{y}\times 100\right) + \frac{1}{2}\left(\frac{\Delta t}{t}\times 100\right)$$

$$\frac{\Delta Q}{Q}\times 100 = \left(\frac{2}{5}\times 2.5\% + 3\times 0.5\% + 2\% + \frac{1}{2}\times 1\%\right)$$

$$= 5\%$$

510. A student performs an experiment for determination of g $= \left(\frac{4\pi^2 l}{T^2}\right) l \approx 1\text{m}$, and he commits an error of Δl For T he takes the time of n oscillation with the stop watch of least count ΔT and he commits a human error of 0.1 s. For which of the following data, the measurement of g will be most accurate?

	Δl	ΔT	n	Amplitude of Oscillation
(a)	5 mm	0.2 s	10	5 mm
(b)	5 mm	0.2 s	20	5 mm
(c)	5 mm	0.1 s	20	1 mm
(d)	1 mm	0.1 s	50	1 mm

Manipal UGET-2014

Ans. (d) : Acceleration due to gravity (g) = $\frac{4\pi^2 l}{T^2}$

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$$

One will get most accurate result, when n is highest and error in length and time is least.

Hence, option (d) is correct.

511. What is the approximate percentage error in the measurement of time period of a simple pendulum if maximum errors in the measurement of length *l* and gravitational acceleration g are 3% and 7% respectively?

(a) 5% (b) 10%

(c) 2% (d) 3%

UPSEE - 2016

Ans. (a) : We know that time period of a simple pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Where, l = length of pendulum

g = acceleration due to gravity

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Take log and differentiate

$$\frac{\Delta T}{T} = \frac{1}{2}\left[\frac{\Delta l}{l} - \frac{\Delta g}{g}\right]$$

For maximize error consider +ve sign

$$\frac{\Delta T}{T}\times 100 = \frac{1}{2}\left[\frac{\Delta l}{l} + \frac{\Delta g}{g}\right]\times 100$$

$$= \left(\frac{3}{2} + \frac{7}{2}\right)\% = \frac{10}{2}\% = 5\%$$

$$\frac{\Delta T}{T}\times 100 = 5\%$$

512. The relation gives the value of x as x = $\frac{\left(a^3 b^3\right)}{\left(c\sqrt{d}\right)}$

Find the percentage error in x, if the percentage error in a, b, c, d, are 2%, 1%, 2% and 4% respectively :

(a) ± 13% (b) ± 5%

(c) ± 9% (d) ± 8%

UPSEE - 2005

Ans. (a) : Given,

Relation gives value of, $x = \frac{a^3 b^3}{c\sqrt{d}}$

Relative error is–

$$\frac{\Delta x}{x} = \pm 3\frac{\Delta a}{a} \pm 3\frac{\Delta b}{b} \pm \frac{\Delta c}{c} \pm \frac{1}{2}\frac{\Delta d}{d}$$

Percentage error is–

$$\frac{\Delta x}{x}\times 100 = \pm 3\left(\frac{\Delta a}{a}\times 100\right) \pm 3\left(\frac{\Delta b}{b}\times 100\right)$$

$$\pm\left(\frac{\Delta c}{c}\times 100\right) \pm \frac{1}{2}\left(\frac{\Delta d}{d}\times 100\right)$$

$$= \pm 3\times 2 \pm 3\times 1 \pm 1\times 2 \pm \frac{1}{2}\times 4$$

$$= \pm 6 \pm 3 \pm 2 \pm 2$$

% error in x = ±13%

@apna_pdf

513. When the voltage and current in a conductor are measured as (100 ± 4) V and (5 ± 0.2) A, then the percentage of error in the calculation of resistance is

(a) 8% (b) 4%
(c) 20% (d) 10%
(e) 6%

Kerala CEE - 2016

Ans. (a) : Given,

$$(V \pm \Delta V) = (100 \pm 4)V$$
$$(I \pm \Delta I) = (5 \pm 0.2)A$$

We know that,

$$R = \frac{V}{I}$$
$$\frac{\Delta R}{R}\times 100 = \frac{\Delta V}{V}\times 100 + \frac{\Delta I}{I}\times 100$$
$$= \frac{4}{100}\times 100 + \frac{0.2}{5}\times 100$$

% error in resistance = 4% + 4% = 8%

514. A metallic bar of coefficient of linear expansion 10^{-5} K^{-1} is heated from 0ºC to 100ºC. The percentage increase in its length is

(a) 0.1 % (b) 1 %
(c) 10 % (d) 0.01 %
(e) 0.001 %

Kerala CEE - 2015

Ans. (a) : Given,

$$\alpha = 10^{-5}\ K^{-1}$$
$$\Delta T = 100° - 0° = 100°C$$
$$\because \quad \Delta l = l\alpha\Delta T$$
$$\frac{\Delta l}{l} = \alpha \times \Delta T$$
$$\frac{\Delta l}{l}\times 100\% = \alpha \times \Delta T \times 100$$
$$= 10^{-5} \times 100 \times 100$$
$$= 10^{-5} \times 10^{4}$$

% increase in length = 0.1%

515. In a simple pendulum experiment, the maximum percentage error in the measurement of length is 2% and that in the observation of the time-period is 3 % then, the maximum percentage error in determination of the acceleration due to gravity g is

(a) 5% (b) 6%
(c) 7% (d) 8%
(e) 10%

Kerala CEE- 2014

Ans. (d) : Given,

$$\frac{\Delta l}{l}\times 100 = 2\%, \frac{\Delta T}{T}\times 100 = 3\%, \frac{\Delta g}{g}\times 100 = ?$$

We know that,

$$\text{Time period } (T) = 2\pi\sqrt{\frac{l}{g}}$$
$$g = \frac{4\pi^2 l}{T^2}$$

Taking log and differentiating of both side

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} - 2\frac{\Delta T}{T}$$

For maximum percentage error is +ve sign

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$$
$$\frac{\Delta g}{g} = 2\% + 2\times 3\%$$
$$= 2\% + 6\%$$
$$= 8\%$$

516. The percentage error in measuring M, L and T are 1 %, 1.5% and 3% respectively. Then the percentage error in measuring the physical quantity with dimensions $[ML^{-1}T^{-1}]$ is

(a) 1% (b) 3.5%
(c) 3% (d) 4.5%
(e) 5.5%

Kerala CEE- 2013

Ans. (e) : Error in Measuring the quantity $[M^a L^b T^c]$

$$= \left[|a|\frac{\Delta M}{M} + |b|\frac{\Delta L}{L} + |c|\frac{\Delta T}{T}\right]\times 100$$

Given,

$$\frac{\Delta M}{M}\times 100 = 1\%, \frac{\Delta L}{L}\times 100 = 1.5\%, \frac{\Delta T}{T}\times 100 = 3\%$$

For dimensions $[ML^{-1}T^{-1}]$

$$\%\text{ Error} = (1\times 1\%) + (1\times 1.5\%) + (1\times 3\%)$$
$$\%\text{ Error} = (1 + 1.5 + 3)\% = 5.5\%$$

517. If the time period of oscillation of a pendulum is measured as 2.5 s using a stop watch with the least count $\frac{1}{2}$ s, then the permissible error in the measurement is

(a) 10% (b) 30%
(c) 15% (d) 25%
(e) 20%

Kerala CEE 2012

Ans. (e) : We have,

$$\frac{\Delta t}{t} = \frac{0.5}{2.5} = \frac{1}{5}$$
$$\frac{\Delta t}{t}\times 100\% = \frac{1}{5}\times 100 = 20\%$$

518. The mass and volume of a body are found to be 5.00 ± 0.05 kg and 1.00 ± 0.05 m^3 respectively. Then the maximum possible percentage error in its density is

(a) 6% (b) 3%
(c) 10% (d) 5%
(e) 7%

Kerala CEE - 2011

@apna_pdf

Ans. (a) : Given, $(m \pm \Delta m) = (5 \pm 0.05)$

$(v \pm \Delta v) = (1.00 \pm 0.05)$

We know,

$$P=\frac{m}{V}$$

taking log and differenting of both side

$$\frac{\Delta P}{P}=\frac{\Delta M}{M}-\frac{\Delta V}{V}$$

for maximum percentage error is +ve sign

$$\frac{\Delta P}{P}=\frac{\Delta m}{m}+\frac{\Delta v}{v}$$

$$\frac{\Delta P}{P}\times 100=\frac{0.05}{5}\times 100+\frac{0.05}{1}\times 100$$

$$= 6\%$$

% error in density = 6%

519. The percentage errors in the measurement of length and time period of a simple pendulum are 1% and 2% respectively. Then the maximum error in the measurement of acceleration due to gravity is

(a) 8%
(b) 3%
(c) 4%
(d) 6%
(e) 5%

Kerala CEE - 2009

Ans. (e) : We know that,

$$\text{Time period } (T)=2\pi\sqrt{\frac{l}{g}}$$

$$\frac{\Delta T}{T}=\pm\frac{1}{2}\left(\frac{\Delta l}{l}+\frac{\Delta g}{g}\right)$$

$$\frac{\Delta g}{g}=\pm\left(\frac{\Delta l}{l}+\frac{2\Delta T}{T}\right)$$

Maximum percentage error in g,

$$\frac{\Delta g}{g}\times 100=\frac{\Delta l}{l}\times 100+\frac{2\Delta T}{T}\times 100$$

$$= 1\% + 2 \times 2\%$$

$$= 5\%$$

520. The values of two resistors are R_1 = (6 ± 0.3) kΩ and R_2 = (10 ± 0.2) kΩ. The percentage error in the equivalent resistance when they are connected in parallel is

(a) 5.125%
(b) 2%
(c) 3.125%
(d) 7%
(e) 10.125%

JCECE-2014
Kerala CEE 2007

Ans. (e) : Given,

$R_1 = (6 \pm 0.3)$ kΩ, $R_2 = (10 \pm 0.2)$ kΩ

The equivalent resistance of parallel combination,

$$R'=\frac{R_1R_2}{R_1+R_2}$$

Taking log on both side and differentiating

$$\log R' = \log(R_1R_2) - \log(R_1 + R_2)$$
$$= \log R_1 + \log R_2 - \log(R_1 + R_2)$$

The fractional error in the value of R',

$$\frac{\Delta R'}{R'}=\frac{\Delta R_1}{R_1}+\frac{\Delta R_2}{R_2}-\frac{\Delta(R_1+R_2)}{(R_1+R_2)}$$

∴ The maximum fractional error in the value of R',

$$\left|\frac{\Delta R'}{R'}\right|_{max}=\frac{\Delta R_1}{R_1}+\frac{\Delta R_2}{R_2}+\frac{\Delta(R_1+R_2)}{(R_1+R_2)}$$

$$=\frac{0.3}{6}+\frac{0.2}{10}+\frac{0.5}{16}$$

$$= 0.05 + 0.02 + 0.03125$$

$$\left|\frac{\Delta R'}{R'}\right|_{max}=0.10125$$

$$\left|\frac{\Delta R'}{R'}\right|_{max}\times 100=0.10125\times 100=10.125\%$$

521. A physical quantity P is related to four measurable quantities a, b, c, and d as follows

$$P=\frac{a^3b^2}{\sqrt{c}\,d}$$

The percentage errors of measurement in a, b, c, and d are 1%, 3%, 4% and 2%. The percentage error in the quantity p is :

(a) 10%
(b) 13%
(c) 5%
(d) 15%
(e) 17%

Kerala CEE 2006

Ans. (b) : Given,

$$P=\frac{a^3b^2}{\sqrt{c}\,d}=a^3b^2c^{-\frac{1}{2}}d^{-1}$$

The fractional error in the value of P,

$$\frac{\Delta P}{P}=\frac{3\Delta a}{a}+\frac{2\Delta b}{b}-\frac{1}{2}\frac{\Delta c}{c}-\frac{\Delta d}{d}$$

For Maximum fractional error is +ve sing in P,

$$\left(\frac{\Delta P}{P}\right)_{max}=3\frac{\Delta a}{a}+\frac{2\Delta b}{b}+\frac{1}{2}\frac{\Delta c}{c}+\frac{\Delta d}{d}$$

The percentage error in P is

$$\left(\frac{\Delta P}{P}\right)_{max}\times 100=3\left(\frac{\Delta a}{a}\times 100\right)+2\left(\frac{\Delta b}{b}\times 100\right)+\frac{1}{2}\left(\frac{\Delta c}{c}\times 100\right)+\left(\frac{\Delta d}{d}\times 100\right)$$

$$\left(\frac{\Delta P}{P}\right)_{max}\times 100=3\times(1\%)+2(3\%)+\frac{1}{2}(4\%)+2\%$$

$$= 3\% + 6\% + 2\% + 2\% = 13\%$$

522. A physical quantity A is related to four observables a, b, c and d as follows:

$$A=\frac{a^2b^3}{c\sqrt{d}}$$

The percentage errors of measurement in a, b, c and d are 1%, 3%, 2% and 2% respectively. What is the percentage error in the quantity A?

(a) 12%
(b) 7%
(c) 5%
(d) 16%
(e) 14%

Kerala CEE 2005

@apna_pdf

Ans. (e) : Given, equation is,

$$A = \frac{a^2b^3}{c\sqrt{d}}$$

taking log of both side and differentiating

$$\log A = 2\log a + 3\log b - \log c - \frac{1}{2}\log d$$

$$\frac{\Delta A}{A} = 2\frac{\Delta a}{a} + 3\frac{\Delta b}{b} - \frac{\Delta c}{c} - \frac{1}{2}\frac{\Delta d}{d}$$

for maximum error is +ve sign

$$\%\text{error in } A = \left(\frac{2\Delta a}{a} + \frac{3\Delta b}{b} + \frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}\right)\times 100$$

$$= \left(2\times 1\% + 3\times 3\% + 2\% + \frac{1}{2}\times 2\%\right)$$

$$= 2\% + 9\% + 2\% + 1\% = 14\%$$

523. In an experiment to measure the height of a bridge by dropping stone into water underneath if the error in measurement of time is 0.1 s at the end of 2 s, then the error in estimation of height of bridge will be:

(a) 0.49 m (b) 0.98 m
(c) 1.37 m (d) 1.96 m
(e) 2.12 m

Kerala CEE 2004

Ans. (d) : Given, $\Delta t = 0.1\text{sec}$, $t = 2$ sec

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 + \frac{1}{2}\times(9.8)(2)^2 \qquad \because u = 0$$

$$h = 19.6\text{m}$$

In terms of relative error,

$$h = \frac{1}{2}gt^2$$

taking log and differentiating

log h = 2 log t

$$\frac{\Delta h}{h} = 2\left(\frac{\Delta t}{t}\right) = 2\left(\frac{0.1}{2}\right) = \frac{1}{10}$$

$$\Delta h = \frac{h}{10} = \frac{19.6}{10}$$

$$\Delta h = 1.96\text{ m}$$

524. A physical quantity x is represented by X = $[M^{\eta}L^{-\theta}T^{-\phi}]$. The maximum percentage errors in the measurement of M, L and T, respectively are α%β% and γ%. The maximum percentage error in the measurement of X will be

(a) $(\eta\alpha - \theta\beta - \phi\gamma)\%$

(b) $(\theta\beta + \phi\gamma - \eta\alpha)\%$

(c) $\left(\frac{\alpha}{\eta} - \frac{\beta}{\theta} - \frac{\gamma}{\phi}\right)\%$

(d) $(\eta\alpha + \theta\beta + \phi\gamma)\%$

JCECE-2015

Ans. (d) : According to the question –

$$X = \left[M^{\eta}L^{-\theta}T^{-\phi}\right]$$

So, maximum error in X,

$$\therefore \frac{\Delta X}{X}\times 100$$

$$= \eta\left(\frac{\Delta M}{M}\times 100\right) + \theta\left(\frac{\Delta L}{L}\times 100\right) + \phi\left(\frac{\Delta T}{T}\times 100\right)$$

$$\frac{\Delta X}{X}\times 100 = \eta(\alpha) + \theta(\beta) + \phi(\gamma)$$

∴ Maximum percentage error in measurement of X

= $(\eta\alpha + \theta\beta + \phi\gamma)\%$.

525. The period of oscillation of a simple pendulum is given by T = $2\pi\sqrt{\frac{l}{g}}$, where *l* is about 100 cm and is known to have 1 mm accuracy. The period is about 2s. The time of 100 oscillations is measured by a stop watch of least count 0.1 s. The percentage error in g is

(a) 0.1 % (b) 1%
(c) 0.2% (d) 0.8%

JCECE-2008

Ans. (c) : We know that,

$$\text{Time period of simple pendulum } (T) = 2\pi\sqrt{\frac{l}{g}}$$

$$T^2 = 4\pi^2\frac{l}{g}$$

$$g = \frac{4\pi^2 l}{T^2}$$

taking log and differentiating

log g = log l – 2 log T

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} - 2\frac{\Delta T}{T}$$

for maximum error is +ve sign

$$\left|\frac{\Delta g}{g}\right|_{\max} = \frac{\Delta L}{L} + \frac{2\Delta T}{T} \qquad \text{.....(i)}$$

Now,

$$\frac{\Delta L}{L} = \frac{1\text{mm}}{100\text{cm}} = \frac{1}{1000}$$

$$\frac{2\Delta T}{T} = \frac{0.1\times 2}{100\times 2} = \frac{1\times 2}{1000\times 2} = \frac{1}{1000}$$

Putting this value of equation (i), we get–

$$\left|\frac{\Delta g}{g}\right|_{\max} = \frac{1}{1000} + \frac{1}{1000} = \frac{2}{1000}$$

$$\frac{\Delta g}{g}\times 100 = \frac{2}{1000}\times 100 = 0.2\%$$

526. If percentage decrease in radius of earth is 1% without changing its mass, then percentage change in acceleration due to gravity is:

(a) 2% decrease (b) 2% increase
(c) 1% decrease (d) 1% increase

JCECE-2006

@apna_pdf

Ans. (b) : $R' = R - \frac{R}{100} = \frac{99R}{100} = 0.99R$ .....(i)

$\because \quad g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2}$

So, max. error in value g,

$$\left|\frac{\Delta g}{g}\right|_{max} = 2\frac{\Delta R}{R} = 2\times\frac{R-0.99R}{R} = 0.01\times 2$$

$$\left|\frac{\Delta g}{g}\right|_{max} = 0.02$$

$$\left|\frac{\Delta g}{g}\right|_{max} \times 100 = 0.02\times 100 = 2\%$$

Therefore, % change in the acceleration due to gravity (g) when the radius of earth is decrease by 1% without changing the mass will be 2% increase.

527. The radius of sphere is measured to be (2.1 ± 0.5) cm. Calculate its surface area with error limits:

(a) $(55.4 \pm 26.4)\ cm^2$
(b) $(55.4 \pm 0.02)\ cm^2$
(c) $(55.4 \pm 2.64)\ cm^2$
(d) $(55.4 \pm 0.26)\ cm^2$

JCECE-2005

Ans. (a) : The surface area of the sphere,

$A = 4\pi r^2$ …(i)

Given, $r = 2.1$ cm

$\Delta r = 0.5$ cm

$A = 4\pi(2.1)^2$

$A = 55.4\ cm^2$ …(ii)

Now,

$$\frac{\Delta A}{A} = 2\times\frac{\Delta r}{r} \quad \ldots(iii)$$

By placing all the values in equation (iii), we get–

$$\frac{\Delta A}{55.4} = 2\times\frac{0.5}{2.1}$$

$$\Delta A = 2\times\frac{0.5}{2.1}\times 55.4 = 26.4\ cm^2$$

Surface area, $= (55.4 \pm 26.4)\ cm^2$

528. A body accelerates from rest with a uniform acceleration *a* for time *t*. The uncertainty in '*a*' is 8% and the uncertainty in '*t*' is 4%. The uncertainty in the speed is

(a) 32%
(b) 12%
(c) 8%
(d) 2%

COMEDK 2015

Ans. (b): We know that the first equation of motion is

$v = u + at$

$\because \quad u = 0$

$v = at$

taking log and differentiating

$\log v = \log a + \log t$

$$\frac{\Delta v}{v} = \frac{\Delta a}{a} + \frac{\Delta t}{t}$$

for error calculation

$$\frac{\Delta v}{v}\times 100 = \pm\left(\frac{\Delta a}{a}\times 100 + \frac{\Delta t}{t}\times 100\right)$$

$$= \pm(8\% + 4\%) = \pm 12\%$$

529. Assertion: When percentage errors in the measurement of mass and velocity are 1% and 2% respectively, the percentage error in K.E. is 5%.

Reason: $\frac{\Delta E}{E} = \frac{\Delta m}{m} + \frac{2\Delta v}{v}$

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2010

Ans. (a) : We know that,

Kinetic Energy, $K.E = \frac{1}{2}mv^2$

taking log and Differentiating of Both side

$$\frac{\Delta E}{E} = \frac{\Delta m}{m} + \frac{2\Delta v}{v}$$

$$\frac{\Delta E}{E}\times 100 = \frac{\Delta m}{m}\times 100 + 2\frac{\Delta V}{V}\times 100$$

$= 1\% + 2 \times 2\% = 5\%$

530. Assertion: The error in the measurement of radius of the sphere is 0.3%. The permissible error in its surface area is 0.6%

Reason: The permissible error is calculated by the formula $\frac{\Delta A}{A} = \frac{4\Delta r}{r}$

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2008

Ans. (c) : We know that,

Area of sphere, $A = 4\pi r^2$

taking log and differentiating

$$\frac{\Delta A}{A} = \frac{2\Delta r}{r}$$

$$\frac{\Delta A}{A}\times 100 = 2\times 0.3\% = 0.6\%$$

The permissible error is not calculated by

$$\frac{\Delta A}{A} = \frac{4\Delta r}{r}$$

So, Reason is not correct.

@apna_pdf

531. The heat generated in a circuit is given by Q = I^2 Rt, where I is current, R is resistance and t is time. If the percentage errors in measuring I, R and t is 2%, 1% and 1% respectively, then the maximum error in measuring heat will be

(a) 2% (b) 3%
(c) 4% (d) 6%

AIIMS-26.05.2018(M)
BITSAT-2020

Ans. (d) : Generated heat, $Q = I^2Rt$

taking log and differentiating

log Q = 2 log I + log R + log t

$$\frac{\Delta Q}{Q} = 2\frac{\Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t}$$

$$\frac{\Delta Q}{Q}\times 100 = \frac{2\Delta I}{I}\times 100 + \frac{\Delta R}{R}\times 100 + \frac{\Delta t}{t}\times 100$$

$$= 2\times 2\% + 1\% + 1\% = 6\%$$

532. The least count of a stop watch is 0.2 second. The time of 20 oscillations of a pendulum is measured to be 25 second. The percentage error in the measurement of time will be

(a) 8% (b) 1.8%
(c) 0.8% (d) 0.1%

AIIMS-2015

Ans. (c) : Given,

Least count of stop watch = [ΔT] = 0.2 sec

No. of Oscillation (n) = 20

Time taken = 25 sec

∴ Time Period of oscillation (T) = $\frac{25}{20}$

= 1.25 sec

$$\% \text{ error} = \frac{\Delta T}{T\times n}\times 100 = \frac{0.2}{1.25\times 20}\times 100$$

= 0.8%

533. The density of a cube is measured by measuring its mass and length of its sides. If the maximum error in the measurement of mass and length are 4% and 3% respectively, the maximum error in the measurement of density will be

(a) 7% (b) 9%
(c) 12% (d) 13%

AIIMS-2013

Ans. (d) : Given that

$$\frac{\Delta m}{m}\times 100 = 4\%$$

$$\frac{\Delta l}{l}\times 100 = 3\%$$

then,

$$\rho = \frac{m}{v} = \frac{m}{l^3}$$

taking log and differentiating

log ρ = log m – 3 log l

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} - 3\frac{\Delta t}{t}$$

For maximum (+ve sign) % error in density measurement,

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta l}{l}$$

$$\frac{\Delta\rho}{\rho}\times 100 = \left(\frac{\Delta m}{m} + 3\frac{\Delta l}{l}\right)\times 100$$

$$= \frac{\Delta m}{m}\times 100 + 3\frac{\Delta l}{l}\times 100$$

= 4 + (3×3) = 13%

534. What is the fractional error in g calculated from $T = 2\pi\sqrt{\ell/g}$? Given fraction errors in T and l are ± x and ± y respectively?

(a) x + y (b) x – y
(c) 2x + y (d) 2x – y

AIIMS-2012

Ans. (c) : $T = 2\pi\sqrt{\frac{l}{g}}$

Squaring both side

$$T^2 = \left(2\pi\sqrt{\frac{l}{g}}\right)^2$$

$$g = \frac{4\pi^2 l}{T^2}$$

$$g \propto \frac{l}{T^2}$$

taking log and differentiating

log g = log l – 2 log T

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} - 2\frac{\Delta T}{T}$$

for maximum error is +ve sign

$$\% \text{ Error, } \frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$$

$$\frac{\Delta g}{g} = y + 2x$$

535. A physical quantity Q is found to depend on observables x, y and z obeying relation $Q = \frac{x^3y^2}{z}$. The percentage error in the measurements of x, y and z are 1%, 2% and 4% respectively. What is percentage error in the quantity Q ?

(a) 4% (b) 3%
(c) 11% (d) 1%

Karnataka CET-2014

Ans. (c) : Given, $Q = \frac{x^3y^2}{z}$

So, max. % error in value Q,

$$\frac{\Delta Q}{Q}\times 100 = 3\left|\frac{\Delta x}{x}\right|\times 100 + 2\left|\frac{\Delta y}{y}\right|\times 100 + \left|\frac{\Delta z}{z}\right|\times 100$$

@apna_pdf

Where, $\frac{\Delta x}{x} = 1\%$

$\frac{\Delta y}{y} = 2\%$

$\frac{\Delta z}{z} = 4\%$

$$\frac{\Delta Q}{Q} \times 100 = 3 \times 1\% + 2 \times 2\% + 1 \times 4\%$$

$= 3\% + 4\% + 4\%$

$= 11\%$

536. If the length of rod A is 3.25 ± 0.01 cm and that of B is 4.19 ± 0.01 cm, then the rod B is longer than rod A by

(a) 0.94 ± 0.00 cm (b) 0.94 ± 0.01 cm
(c) 0.94 ± 0.02 cm (d) 0.94 ± 0.005 cm

J&K CET- 2005

Ans. (c) : Length of rod A (L_A) = (3.25 ± 0.01)cm

Length of rod B (L_B) = (4.19 ± 0.01)cm

$$L_B - L_A = \left(L_{B_{mean}} - L_{A_{mean}}\right) \pm \left(\Delta L_{A_{mean}} + \Delta L_{B_{mean}}\right)$$

$$L_B - L_A = \left[(4.19 - 3.25) \pm (0.01 + 0.01)\right]\text{cm}$$

$$L_B - L_A = (0.94 \pm 0.02)\text{cm}$$

537. A physical quantity z, depends upon two other physical quantities x and y, as follows. $z = ax^2y^{1/2}$ where, a is a constant. In an experiment, the quantity x is determined by measuring z and y, and using the above expression. If the percentage of error in the measurement of z and y are 10% and 12% respectively, then the percentage of error in the determined value of x is

(a) 2%
(b) 8%
(c) 15%
(d) Without the value of the constant a, the percentage of error cannot be calculated

J&K-CET-2012

Ans. (a) : Given,

$$z = ax^2y^{\frac{1}{2}}$$

taking log and differentiating

$\log z = 2 \log x + \frac{1}{2} \log g$

$$\frac{\Delta z}{z} = 2\frac{\Delta x}{x} + \frac{1}{2}\frac{\Delta y}{y}$$

$$\frac{\Delta z}{z} \times 100 = \left[2\frac{\Delta x}{x} + \frac{1}{2}\frac{\Delta y}{y}\right] \times 100$$

Given, $\frac{\Delta z}{z} \times 100 = 10\%$, $\frac{\Delta y}{y} \times 100 = 12\%$

$$10\% = 2\frac{\Delta x}{x} \times 100 + \frac{1}{2} \times 12\%$$

$$10\% = 2\frac{\Delta x}{x} \times 100 + 6\%$$

$$2\frac{\Delta x}{x} \times 100 = 10\% - 6\% = 4\%$$

$$\frac{\Delta x}{x} \times 100 = \frac{4\%}{2} = 2\%$$

538. If the error in measuring the radius of the sphere is 2% and that in measuring its mass is 3%, then the error in measuring the density of material of the sphere is

(a) 5% (b) 7%
(c) 9% (d) 11%

J&K-CET-2016

Ans. (c) : Density (ρ) = $\frac{\text{mass}(m)}{\text{volume}(V)}$

$$\rho = \frac{m}{\frac{4}{3}\pi R^3} = \frac{3}{4}\frac{m}{\pi R^3}$$

$$\frac{\Delta\rho}{\rho} \times 100 = \left(\frac{\Delta m}{m} + 3\frac{\Delta R}{R}\right) \times 100$$

$= 3\% + 3\,(2\%)$

$= 3\% + 6\%$

$= 9\%$

(e) Significant Figure

539. The final result of the sum of the numbers 523.32, 1.21525 and 107.3 rounded to correct significant figures is :

(a) 631.8 (b) 631.835
(c) 631.83 (d) 631.8352
(e) 631.83524

Kerala CEE 04.07.2022

Ans. (a) : from the question –
523.32+1.21524+107.3
= 523.32000+1.21524+107.30000
= 631.83524 = 631.8
The final result of the sum of the numbers rounded to correct significant figures is 631.8

540. The number of significant figures in quantity 0.00005041 J is

(a) 9 (b) 4
(c) 3 (d) 10

AP EAMCET-07.07.2022, Shift-I

Ans. (b) : $0.00005041 = 5041 \times 10^{-8}$
Significant digit = 5041
Only 4 significant figures

541. If N_A, N_B and N_C are the number of significant figures in A = 0.001204 m, B = 43120000 m and C = 1.200 m respectively then

(a) $N_A = N_B = N_C$ (b) $N_A > N_B > N_C$
(c) $N_A < N_B < N_C$ (d) $N_A > N_B < N_C$

AP EAMCET-04.07.2022, Shift-I

@apna_pdf

Ans. (a) :
0.001204 contains 4 significant figure i.e. $N_A = 4$
43120000 contains 4 significant figure i.e. $N_B = 4$
1200 contains 4 significant figure i.e. $N_C = 4$

Hence, $N_A = N_B = N_C$

542. The number of significant figures in the quantity 5.6200 J is

(a) 3 (b) 5
(c) 2 (d) 4

AP EAMCET-11.07.2022, Shift-II

Ans. (b) : As we know zeroes only after a non-zero digit, after the decimal, and zeroes between any two non-zero digits are significant.
Therefore, the answer is 5.

543. The radius of a circular plate is 1.05 m. Its area (in m^2) up to correct significant figures is

(a) 3.47 (b) 3.475
(c) 3.467 (d) 3.82
(e) 3.825

Kerala CEE 2021

Ans. (a) : Radius of circle (R) = 1.05m
Area of Circle = πR^2

$$= \frac{22}{7} \times (1.05)^2$$

Number of significant in 3.465 should be equal to number of significant radius 3.47 in area (up to correct significant figures).

544. What is the number of significant figures in $(3.20 + 4.80) \times 10^5$

(a) 2 (b) 3
(c) 4 (d) 5

AP EAMCET-07.09.2021, Shift-I

Ans. (b) :3.20 has '3' significant figures 4. 80 has '3' significant figures. Therefore, there is 3 significant Figure's because 10^5 has no singeficant figures.

545. For the four sets of three measured physical quantities as given below. Which of the following options is correct ?

(i) $A_1 = 24.36, B_1 = 0.0724, C_1 = 256.2$
(ii) $A_2 = 24.44, B_2 = 16.082, C_3 = 240.2$
(iii) $A_3 = 25.2, B_3 = 19.2812, C_3 = 236.183$
(iv) $A_4 = 25, B_4 = 236.191, C_4 = 19.5$

(a) $A_1 + B_1 + C_1 < A_3 + B_3 + C_3$
$< A_2 + B_2 + C_2 < A_4 + B_4 + C_4$
(b) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1$
$= A_2 + B_2 + C_2$
$= A_3 + B_3 + C_3$
(c) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1$
$= A_3 + B_3 + C_3 < A_2 + B_2 + C_2$
(d) $A_1 + B_1 + C_1 = A_2 + B_2 + C_2$
$= A_3 + B_3 + C_3 = A_4 + B_4 + C_4$

JEE Main-09.06.2020, Shift-II

Ans. (*) :

$$A_1 + B_1 + C_1 = 280.632$$
$$A_2 + B_2 + C_2 = 280.72$$
$$A_3 + B_3 + C_3 = 280.664$$
$$A_4 + B_4 + C_4 = 280.691$$
$$A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_4 + B_4 + C_4 < A_2 + B_2 + C_2$$

546. Taking into account of the significant figures, what is the value of 9.99 m − 0.0099 m?

(a) 9.98 m (b) 9.980 m
(c) 9.9 m (d) 9.9801 m

[NEET (Sep.) 2020]

Ans. (a) :

$$\begin{array}{r} 9.9900 \\ -\ \ 0.0099 \\ \hline 9.9801 \end{array}$$

Since least number of significant figure persent in given numbers in 2, hence,

$$9.99\text{m} - 0.0099\text{m} = 9.98\text{m}$$

547. The diameter and height of a cylinder are measured by a meter scale to be 12.6 ± 0.1 cm and 34.2 ± 0.1cm, respectively. What will be the value of its volume in appropriate significant figures ?

(a) $4300 \pm 80\text{cm}^3$ (b) $4260 \pm 80\text{cm}^3$
(c) $4264.4 \pm 81.0\text{cm}^3$ (d) $4264 \pm 81\text{cm}^3$

JEE Main-10.06.2019, Shift-II

Ans. (b) :
Diameter (D) $= 12.6 \pm 0.1\text{cm}$ (Significant figure = 3)
Height (h) $= 34.2 \pm 0.1\text{cm}$ (Significant figure = 3)
Volume (V) $= \pi r^2 h$

$$= \frac{\pi D^2 h}{4} \qquad \left(\because r = \frac{D}{2}\right)$$
$$= \frac{3.14 \times 12.6^2 \times 34.2}{4}$$
$$= 4262.2 \text{ cm}^3$$
$$= 4260 \qquad \text{(three significant number)}$$

Now, $$\frac{\Delta V}{V} = 2\frac{\Delta D}{D} + \frac{\Delta h}{h}$$

$$\Delta V = V\left(2\frac{\Delta D}{D} + \frac{\Delta h}{h}\right)$$
$$= 4262.2\left(2 \times \frac{0.1}{12.6} + \frac{0.1}{34.2}\right)$$
$$= 4262.2(0.0158 + 0.0029)$$
$$= 4262.2 \times 0.01879 = 79.8$$
$$= 79.8$$
$$\approx 80$$

Hence, Volume (V) $= 4260 \pm 80\text{cm}^2$

@apna_pdf

548. The area of a square is 5.29 cm^2. The area of 7 such squares taking into account the significant figures is

(a) 37.030 cm^2 (b) 37.0 cm^2
(c) 37.03 cm^2 (d) 37 cm^2

JEE Main-09.04.2019, Shift-II

Ans. (b) : Given,

Area of a square (A) $= 5.29\text{cm}^2$

Total area = $A_1 + A_2 + \ldots\ldots A_7$

$= A + A + \ldots\ldots$ 7 times

$= 7A = 7\times5.29 = 37.03\text{ cm}^2$

The result should have three signification figure.

Hence, A = 37.0 cm^2

549. Identify the incorrect statement among the following.

(a) A true length of 5.678 km has been measured in two experiments as 5.5 km and 5.51 km, respectively. The second measurement has more precision.
(b) Length of 1 m and 0.5 m have been both measured with the same absolute error of 0.01 m. Both the measurement are equally accurate.
(c) The numbers of significant digits in 1.6 and 0.60 are both two.
(d) The number 2.445 can be rounded to two decimal place as 2.45.

TS-EAMCET-03.05.2019, Shift-1

Ans. (b, d) : As the second measured value i.e, 5.51 km is more closed to the result i.e, 5.678 km.

So, it is more precise. Hence, the statement (a) is correct.

The percentage error of in case of 1m length is–

$$\text{\% Error in 1 m length} = \frac{\Delta l_1}{l_1}\times100 = \frac{0.01}{1}\times100 = 1\%$$

$$\text{\% Error in 0.5 m length} = \frac{\Delta l_2}{l_2}\times100 = \frac{0.01}{0.05}\times100 = 2\%$$

Hence, the statement (b) is incorrect.

No. of significant in 1.6 = (1, 6) = 2 significant figure

And no. of significant in 0.60 = (6,0) = 2 significant figure

Hence, the statement (c) is correct.

The number 2.445 can be rounded to two decimal place as 2.44.

Hence, the statement (d) is incorrect.

So, option (b) and (d) will be incorrect.

550. Number of significant figures in expression $\frac{4.327\text{g}}{2.51\text{cm}^3}$ is

(a) 2 (b) 4
(c) 3 (d) 5

BITSAT-2019

Ans. (c) : Number of significant figures in $\frac{4.327}{2.51}$

$= 1.7239 = 1.72$

(1, 7, 2) there are three significant figure

551. Assertion (A) : The number 0.00764 has three significant figures.

Reason (R) : If the number is less than 1, the zeros on the right of the decimal point but to the left of the first non-zero digit are not significant.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(c) (A) is true but (R) is false.
(d) (A) is false but (R) is true.

AP EAMCET (23.04.2019) Shift-I

Ans. (a) : For Assertion (A):-

No. of significant figure in 0.00764

= (7, 6, 4)

There are 3 significant figure in above number

For reason (R):-

Let a number is

$$0.\underset{\substack{\downarrow\\ \text{Non}-\text{significant (Left zeros)}}}{\boxed{00}}\text{abc}\boxed{00}\rightarrow\text{significant (Right zeros)}$$

552. The value of resistance is 10.845Ω and the current is 3.23 A. On multiplying, we get the potential difference is 35.02935 V. The value of potential difference in terms of significant figures would be

(a) 35 V (b) 35.0 V
(c) 35.029 V (d) 35.03 V

COMEDK 2019

Ans. (b): Resistance (R) = 10.845 Ω

Current (I) = 3.23 A

V = IR (By Ohm's law)

Where, V = Voltage, I = Current, R = Resistance

V = 10.845 × 3.23 = 35.02 935 V

Rounding of the value of potential difference to retain their significant figure in result = 35.0 volt.

Since, (1). If it less than 5, drop it and all the figure to the right of it.

(2). If it is more than 5, increased by 1 the number to be rounded, that is the proceeding figure.

Hence, 2 is less than 5, then the proceeding figure is same.

553. Assertion: Number of significant figures in 0.005 is one and that in 0.500 is three

Reason: This is because zeros are not significant.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

@apna_pdf

Ans. (c) : No. of significant in 0.005
= (digit 5)
= only 1 significant figure
No. of significant in 0.500
= (5, 0, 0)
= 3 significant figure
So, Zeroes placed to the left of the number are never significant, but zeroes places to right of the number are significant.
Hence, assertion is true but reason is false.

554. Two intervals of time are measured as $\Delta t_1 = (2.00 \pm 0.02)$ s and $\Delta t_2 = (4.00 \pm 0.02)$s. The value of with $\sqrt{(\Delta t_1)(\Delta t_2)}$ with correct significant figures and error is

(a) (2.828 ± 0.01)s (b) (2.83 ± 0.02)s
(c) (2.828 ± 0.0075)s (d) (2.83 ± 0.0075)s

AP EAMCET (21.04.2019) Shift-I

Ans. (b) : Given,
$\Delta t_1 = (2.00 \pm 0.02)$ second Δt_1 = 2.00 second,
$\Delta te_1 = \pm 0.02$ second
$\Delta t_2 = (4.00 \pm 0.02)$ second Δt_2 = 4.00 second,
$\Delta te_2 = \pm 0.02$ second

$$\because T = \sqrt{\Delta t_1 \times \Delta t_2}$$
$$T = \sqrt{2.00 \times 4.00} = 2.8284$$
$$T = 2.838$$
$$\frac{\Delta T_e}{\Delta T} = \frac{1}{2}\left(\frac{\Delta te_1}{\Delta t_1} + \frac{\Delta te_2}{\Delta t_2}\right) = \pm \frac{1}{2}\left[\frac{0.02}{2.00} + \frac{0.02}{4.00}\right]$$
$$= \pm \frac{1}{2}[0.01 + 0.005]$$
$$\frac{\Delta T_e}{2.83} = \pm \frac{1}{2}(0.015)$$
$$\Delta T_e = 0.0212258 = 0.02$$
$$T = (2.83 \pm 0.02)\text{second}$$

555. Match the measurements given in List I with the number of significant figures given in List II.

	List-I	List-II	
A	74.083	I.	3
B	0.029	II.	4
C	0.002407	III.	2
D	2.74×10^7	IV.	5

The correct answer is

	A	B	C	D		A	B	C	D
(a)	IV	II	III	I	(b)	IV	III	II	I
(c)	III	IV	II	I	(d)	I	II	III	IV

AP EAMCET (23.04.2018) Shift-2

Ans. (b) : Number of significant figure in 74.083 = (7,4,0,8,3) = 5
Number of significant figure in 0.029 = (2, 9) = 2
Number of significant figure in 0.002407= (2,4,0,7) = 4
Number of significant figure in 2.74×10^7
= (2, 7, 4) = 3

556. The length and diameter of a cylinder are measured to be 10.1031 cm and 2.0935 cm respectively. The volume of the cylinder to an appropriate significant figure is.

(a) 139.04 cm^3 (b) 34.76 cm^3
(c) 134.75 cm^3 (d) 46.35 cm^3

TS EAMCET (Medical)-02.05.2018, Shift-I

Ans. (b) : Given that,
h = 10.1031 cm, d = 2.0935 cm
Since we know that

$$\text{Volume of cylinder } (V) = \frac{\pi}{4}d^2h$$
$$\therefore V = \frac{3.14}{4} \times (2.0935)^2 \times 10.1031$$
$$V = 0.785 \times 4.382 \times 10.1031$$
$$V = 34.759 \text{ cm}^3$$
$$\boxed{V = 34.76 \text{ cm}^3}$$

557. In order to measure the period of a single pendulum using a stop clock, a student repeated the experiment for 10 times and noted down the time period for each experiment as 5.1, 5.0, 4.9, 4.9, 5.1, 5.0, 4.9, 5.1, 5.0, 4.9 s. The correct way of expressing the result for the period is

(a) 4.99 s (b) 5.0 s
(c) 5.00 s (d) 4.9 s
(e) 5.1 s

Kerala CEE - 2017

Ans. (b) : No. of repeated experiment (n) = 10
∴ Period,

$$T = \frac{5.1 + 5.0 + 4.9 + 4.9 + 5.1 + 5.0 + 4.9 + 5.1 + 5.0 + 4.9}{10}$$

T = 4.99 second
Which can be round of to 5.0 second to two significant figure.
So, T = 5.0 second

558. The sides of a rectangle are 7.01 m and 12 m. Taking the significant figures into account, the area of the rectangle is

(a) 84.1 m^2 (b) 84.00 m^2
(c) 84.12 m^2 (d) 84 m^2

UPSEE - 2017

Ans. (d) : Given that,
Length of rectangle =12m
Breadth of rectangle =7.01 m
Area of rectangle = Length × Breadth
= 12 × 7.01
= 84.12 m^2
The area of the rectangle after taking the significant figure = 84 m^2

559. The result of multiplication of 107.88 and 0.610 is :

(a) 65.8068 (b) 65.807
(c) 65.81 (d) 65.8

SRMJEE - 2008

@apna_pdf

Ans. (d) : Given that,

$107.88 \times 0.610 = 65.8068$

Considering significant units, the minimum number of significant units in the given data is 3.

$\Rightarrow$ Product is 65.8.

560. The length, breadth and thickness of a block are given by l = 12 cm, b = 6 cm and t = 2.45cm. The volume of the block according to the idea of significant figures should be

(a) $1 \times 10^2 cm^3$ (b) $2 \times 10^2 cm^3$

(c) $1.763 \times 10^2 cm^3$ (d) None of the above

JIPMER-2005

UPCPMT-2004

Ans. (b) : Given that,

l = 12 cm

b = 6 cm

t = 2.45 cm

Using the relation for volume

$V = l \times b \times t$

$V = 12 \times 6 \times 2.45$

$V = 176.4$

$V = 1.764 \times 10^2$ cm^3

The minimum number of significant figures is one in thickness, hence the volume will contain only one significant figure.

Therefore,

$V = 2 \times 10^2$ cm^3

561. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are

(a) 5, 1, 2 (b) 5, 1, 5

(c) 5, 5, 2 (d) 4, 4, 2

AIEEE 2010

Ans. (a) :

Number of significant figures for 23.023 is 5.

Number of significant figures for 0.0003 is 1

Number of significant figures for 2.1×10^{-3} is 2.

Therefore, the correct sequence is

5, 1, 2.

562. In a system of units, the units of mass, length and time are 1 quintal, 1 km and 1h respectively. In this system 1 N force will be equal to

(a) 1 unit (b) 129.6 unit

(c) 125.7 unit (d) 10^3 unit

UP CPMT-2002

Ans. (b) : 1 kg = 10^{-2} quintal

1 m = 10^{-3} km

$$1 \text{ s} = \frac{1}{3600} \text{ hour}$$

$$1 \text{ N} = \frac{\text{kg} \times \text{m}}{\text{s}^2} = \frac{10^{-2} \times 10^{-3}}{\left(\frac{1}{3600}\right)^2}$$

$1 \text{ N} = 10^{-5} \times 3600 \times 3600$

1 N = 129.6 unit

Hence, unit in quintal, kilometer and hour is 129.6 unit.

563. The number of significant figures in the numbers 4.8000×10^4 and 48000.50 are respectively

(a) 5 and 6 (b) 5 and 7

(c) 2 and 7 (d) 2 and 6

Manipal UGET-2009

Karnataka CET-2009

Ans. (b) : All the non digits are significant. Power of 10 is irrelevant for the determination of significant figures. Hence, 4.8000×10^4 has five significant figures.

Also, all the zeros between two non-zero digits are significant. Hence, 48000.50 has 7 significant figures.

Explanation–No. of significant figures in 4.8000×10^4

= (4,8,0,0,0) [5 significant figures]

No. of significant figures in 48000.50

= (4,8,0,0,0,5,0) [7 significant figures]

564. Find the value of $\frac{1.53 \times 0.9995}{1.592}$ with due regard for significant figures

(a) 0.961 (b) 0.123

(c) 0.921 (d) 0.913

BITSAT-2007

Ans. (a) :

Significant figure rule

$$\frac{1.53 \times 0.9995}{1.592} = \frac{1.529}{1.592} = \frac{1.53}{1.592} = 0.961$$

(9, 6, 1) There are three significant figures.

565. How many significant figures are there in 0.30100?

(a) 1 (b) 3

(c) 5 (d) None of these

BITSAT-2010

Ans. (c) : No. of significant figure in 0.30100

= (3, 0, 1, 0, 0)

= (5 significant figure)

566. A cube has a side of length 1.2×10^{-2} m. Calculate its volume.

(a) 1.7×10^{-6} m^3 (b) 1.73×10^{-6} m^3

(c) 1.70×10^{-6} m^3 (d) 1.732×10^{-6} m^3

UPSEE - 2010

SRMJEE - 2011

Ans. (a) : Given,

Side of cube

$a = 1.2 \times 10^{-2}$ m

So volume of cube = (side)^3

$= (1.2 \times 10^{-2})^3 = 1.728 \times 10^{-6}$ m^3

$= 1.7 \times 10^{-6}$m^3

Since side (a) has two significant figures, the volume (V) will also have two significant figures.

Therefore, the correct answer is $V = 1.7 \times 10^{-6}$ m^3

567. If 3.8×10^{-6} is added to 4.2×10^{-5} giving due regard to significant figures, then the result will be

(a) 4.58×10^{-5} (b) 4.6×10^{-5}

(c) 4.5×10^{-5} (d) None of these

UPSEE - 2009

@apna_pdf

Ans. (b) : Given, 3.8×10^{-6} and 4.2×10^{-5}

By adding,

$$= 3.8 \times 10^{-6} + 4.2 \times 10^{-5}$$
$$= 3.8 \times 10^{-6} + 42 \times 10^{-6}$$
$$= 45.8 \times 10^{-6}$$
$$= 4.58 \times 10^{-5}$$
$$= 4.6 \times 10^{-5}$$

568. The number of significant figures in 0.002305 is

(a) 6 (b) 4
(c) 7 (d) 2
(e) 3

Kerala CEE - 2010

Ans. (b) : The number of significant figures in 0.002305

Digits = (2, 3, 0, 5) = 4 significant figures

$0.\underline{00}2305$

↓

Non-significant figure (Left zeros)

569. Assertion: The number of significant figures depends on the least count of measuring instrument.

Reason: Significant figures define the accuracy of measuring instrument.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2016

Ans. (b) : Significant figure refers to the accuracy of measurement and accuracy of measurement also depend upon the least count of measuring instrument.

570. The mass of a metal cube is 5.74 g and its volume is 1.2 cm^3. Then its density expressed up to appropriate significant figures will be

(a) 4.8 g cm^{-3} (b) 4.78 g cm^{-3}
(c) 4.783 g cm^{-3} (d) 5.0 g cm^{-3}

SCRA-2013

Ans. (a) : As we know that, density $\rho = \dfrac{m}{V}$

Given, $m = 5.74$ g, $V = 1.2$ cm^3

$$\therefore \quad \rho = \frac{5.74}{1.2} = 4.78333\,\text{g/cm}^3$$
$$\approx 4.8\ \text{g/cm}^3$$

571. The length and breadth of a metal sheet are 3.124 m and 3.002 m respectively. The area of this sheet upto four correct significant figure is:

(a) 9.378 m^2 (b) 9.37 m^2
(c) 9.378248 m^2 (d) 9.3782 m^2

AIIMS-2001

Ans. (a) : Given, Length = 3.124 m

Breadth = 3.002 m

Area $= L \times B$

$= 3.124 \times 3.002 = 9.378$ m^2

(f) Measuring Instrument

572. In an experiment of measuring the refractive index of a glass slab using travelling microscope in physics lab, a student measures real thickness of the glass slab as 5.25 mm and apparent thickness of the glass slab as 5.00 mm. Travelling microscope has 20 divisions in one cm on main scale and 50 divisions on vernier scale is equal to 49 divisions on main scale. The estimated uncertainty in the measurement of refractive index of the slab is $\frac{x}{10} \times 10^{-3}$, where is x____

JEE Main-29.01.2023, Shift-II

Ans. (41) : 20 MSD = 10 mm

1 MSD = 0.5 mm

50 VSD = 49 MSD

$$1\ \text{VSD} = \frac{49}{50} \times \text{MSD}$$

Least count (LC) = 1 MSD – 1 VSD

$$= 1\text{MSD} - \frac{49}{50} \times \text{MSD}$$
$$= \frac{\text{MSD}}{50}$$
$$= \frac{0.5}{50}$$
$$= 0.01\ \text{mm} = \Delta h$$

Refractive index of glass slab are

$$\eta_{ga} = \frac{\text{Actual thickness of the glass slab } (h_{\text{actual}})}{\text{Apparent thickness of the glass slab } (h_{\text{apparent}})}$$

$$\eta_{ga} = \frac{h_{\text{actual}}}{h_{\text{apparent}}} = \frac{5.25}{5} = 1.05$$

So, uncertainity measured in refractive index of glass slab is

$$\frac{\Delta\eta_{ga}}{\eta_{ga}} = \frac{\Delta h_{\text{actual}}}{h_{\text{actual}}} + \frac{\Delta h_{\text{apparent}}}{h_{\text{apparent}}} = \frac{.01}{5.25} + \frac{0.01}{5}$$

$$\frac{\Delta\eta_{ga}}{1.05} = 0.01 \times \left(\frac{1}{5.25} + \frac{1}{5}\right)$$

$$\Delta\eta_{ga} = \frac{41}{10} \times 10^{-3}$$

x = 41

573. The Vernier scale of a travelling microscope has 50 divisions which coincides with 49 main scale division. If each main scale division is 0.5 mm, then the lease count of the microscope is

(a) 0.01 mm (b) 0.5 cm
(c) 0.01 cm (d) 0.5 mm

Karnataka CET-2022

@apna_pdf

Ans. (a) : Least count $=\dfrac{\text{MSD}}{\text{No. of vernier scale division}}$

MSD = 0.5 mm

No. of vernier scale division = 50

$$\boxed{\text{LC}=\frac{0.5}{50}=0.01\text{mm}}$$

574. The vernier constant of Vernier callipers is 0.1 mm and it has zero error of (–0.05) cm. while measuring diameter of a sphere, the main scale reading is 1.7 cm and coinciding vernier division is 5. The corrected diameter will be ______ $\times 10^{-2}$ cm.

JEE Main-29.06.2022, Shift-II

Ans. (180) : Given,

Main scale reading (MSR) = 1.7cm

Vernier constant (VC) = 0.1 mm = 0.01cm

Vernier division = 5

So, Vernier Scale Reading (VSR) = 5

Correct diameter = MSR + (VSR) × VC – Error

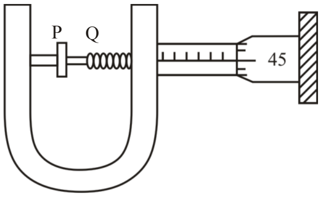
$= 1.7 + 5 \times 0.01 - (-0.05)$

$= 1.75 + 0.05$

$= 1.8$ cm

$= 180 \times 10^{-2}$ cm

575. In an experiment to find out the diameter of wire using screw gauge, the following observation were noted:



(A) Screw moves 0.5 mm on main scale in one complete rotation

(B) Total divisions on circular scale = 50

(C) Main scale reading is 2.5 mm

(D) 45th division of circular scale is in the pitch line

(E) Instrument has 0.03 mm negative error

Then the diameter of wire is:

(a) 2.92 mm (b) 2.54 mm

(c) 2.98 mm (d) 3.45 mm

JEE Main-29.07.2022, Shift-I

Ans. (c) : Pitch = 0.5 mm

Total no. of division on circular scale = 50

Main Scale Reading (MSR) = 2.5 mm

Circular Scale Reading (CSR) = 45

Error = –0.03 mm

Least Count (LC) $=\dfrac{\text{Pitch}}{\text{No. of division on circular scale}}$

$$\text{LC}=\frac{0.5}{50}=0.01\text{mm}$$

Diameter of wire = MSR + CSR × (LC) – (Error)

$= 2.5 + 45 \times 0.01 - (-0.03) = 2.98$mm

576. A travelling microscope has 20 divisions per cm on the main scale while its Vernier scale has total 50 divisions and 25 Vernier scale divisions are equal to 24 main scale divisions, what is the least count of the travelling microscope?

(a) 0.001 cm (b) 0.002 mm

(c) 0.002 cm (d) 0.005 cm

JEE Main-29.07.2022, Shift-I

Ans. (c) : The main scale division is equal to the 20 division per cm.

$\therefore$ 1 cm = 20 MSD

$$1\text{MSD}=\frac{1}{20}\text{cm}$$

and 25 VSD = 24 MSD

or $1\text{VSD}=\dfrac{24}{25}\text{MSD}=\dfrac{24}{25}\times\dfrac{1}{20}\text{cm}$

Least count = 1 MSD – 1 VSD

$$=\left(\frac{1}{20}-\frac{24}{25}\times\frac{1}{20}\right)\ \text{MSD}$$

Least Count $=\dfrac{1}{20}\left(1-\dfrac{24}{25}\right)\text{cm}=\dfrac{1}{20}\times\dfrac{1}{25}=\dfrac{1}{500}\text{cm}$

$= 0.002$cm

577. In a Vernier Callipers. 10 divisions of Vernier scale is equal to the 9 divisions of main scale. When both jaws of Vernier calipers touch each other, the zero of the Vernier scale is shifted to the left of zero of the main scale and 4th Vernier scale division exactly coincides with the main scale reading. One main scale division is equal to 1 mm. While measuring diameter of a spherical body, the body is held between two jaws. It is now observed that zero of the Vernier scale lies between 30 and 31divisions of main scale reading and 6th Vernier scale division exactly coincides with the main scale reading. The diameter of the spherical body will be:

(a) 3.02 cm (b) 3.06 cm

(c) 3.10 cm (d) 3.20 cm

JEE Main-26.07.2022, Shift-II

Ans. (c) : Given that,

Main scale reading (MSR) = 30 mm

Vernier scale reading (VSR) = 6

10 division of vernier scale is equal to the 9 division of main scale

or, 10 VSD = 9 MSD

or $1\text{ VSD}=\dfrac{9}{10}\text{MSD}$

Least count (LC) = 1 MSD – 1 VSD

$$=1\text{ MSD}-\frac{9}{10}\text{MSD}$$

$$=\left(1-\frac{9}{10}\right)\text{MSD}$$

$$=\frac{1}{10}\times 1\text{ mm}\qquad(\because 1\text{ MSD}=1\text{mm})$$

$= 0.1$ mm

@apna_pdf

Vernier scale is shifted to the left of zero of the main scale

So,

$$\text{Negative error} = -4 \times (\text{LC})$$
$$= -4 \times 0.1 \text{ mm}$$
$$= -0.4 \text{ mm}$$

So, diameter = MSR + VSR × (LC) – (Negative error)

$$= 30 + 6 \times 0.1 - (-0.4)$$
$$= 31 \text{ mm}$$
$$= 3.1 \text{ cm}$$

578. The one division of main scale of vernier calipers reads 1 mm and 10 divisions of Vernier scale is equal to the 9 divisions on main scale. When the two jaws of the instrument touch each other the zero of the Vernier lies to the right of zero of the mains scale and its fourth division coincides with a main scale division. When a spherical bob is tightly placed between the two jaws, the zero of the Vernier scale lies between 4.1 cm and 4.2 cm and 6^{th} Vernier division coincides with a main scale division. The diameter of the bob will be —— 10^{-2} cm.

JEE Main-27.07.2022, Shift-I

Ans. (412) : 10 division of vernier scale is equal to the 9 division of main scale.

$$9 \text{ MSD} = 10 \text{ VSD}$$

$$1\text{VSD} = \frac{9}{10}\text{MSD} = \frac{9}{10}\times 1 = \frac{9}{10}\text{mm}$$

Least count (LC) = 1MSD − 1VSD

$$= 1 \text{ MSD} - \frac{9}{10}\text{MSD} = \left(1-\frac{9}{10}\right)\text{MSD}$$

$$= \frac{1}{10}\text{MSD} = \frac{1}{10}\text{mm} \qquad (\because 1\text{MSD} = 1\text{mm})$$

$$= \frac{1}{10}\text{mm} = 0.1\text{mm} = 0.01\text{cm}$$

∵ Vernier scale lies to the right of zero of the main scale

∴ Positive error = 4 × 0.1

= 0.4 mm

= 0.04 cm

Main scale reading (MSR)= 4.1cm

Vernier coincidence = 6

Corrected reading = MSD + (vernier coincidence × LC) – Error

$$= 4.1 + (6 \times 0.01) - 0.04$$
$$= 4.12 \text{ cm}$$
$$= 412 \times 10^{-2}\text{cm}$$

579. In a vernier callipers, each cm on the main divided into 20 equal parts. If tenth vernier scale division coincides with nineth main scale division. Then the value of vernier contant will be ——— $\times 10^{-2}$ mm.

JEE Main-26.06.2022, Shift-I

Ans. (5) :

$$1\text{MSD} = \frac{1\text{cm}}{20} = 0.05\text{cm}$$

10^{th} vernier scale division = 9^{th} main scale division

$$10\text{VSD} = 9\text{MSD}$$

$$1 \text{ VSD} = = \frac{9}{10}\text{MSD}$$

Least count = 1MSD − 1VSD

$$= 1\text{MSD} - \frac{9}{10}\text{MSD}$$

$$= \frac{1}{10}\text{MSD}$$

$$= \frac{1}{10}\times 0.05\text{cm}, \quad (\because 1 \text{ MSD} = 0.05 \text{ cm})$$

$$= 5\times 10^{-2}\text{cm}$$

580. A screw gauge of pitch 0.5mm is used to measure the diameter of uniform wire of length 6.8cm, the main scale reading is 1.5 mm and circular scale reading is 7. The calculated curved surface area of wire to appropriate significant figures is:

[Screw gauge has 50 divisions on the circular scale]

(a) 6.8cm^2 (b) 3.4cm^2

(c) 3.9cm^2 (d) 2.4cm^2

JEE Main-26.07.2022, Shift-I

Ans. (b) : Given that, screw gauge pitch = 0.5mm

Length of wire l = 6.8cm

Circular scale reading = 7

$$\text{Least count} = \frac{0.5}{50}\text{mm} = 0.01\text{mm}$$

Diameter (d) = main scale reading + circular scale reading × Least count

$$d = 1.5\text{mm} + 7\times 0.01$$
$$d = 1.57\text{mm} = 0.157\text{cm}$$

Curved surface area of wire = $\pi d l \text{ cm}^2$

$$= 3.14\times 0.157\times 6.8 \text{ cm}^2$$
$$= 3.35 \text{ cm}^2$$
$$\cong 3.4 \text{ cm}^2$$

581. One main scale division of a vernier callipers is a cm and n^{th} division of the vernier scale coincide with $(n-1)^{th}$ division of the main scale. The least count of the callipers (in mm) is

(a) $\frac{10na}{(n-1)}$ (b) $\frac{10a}{(n-1)}$

(c) $\left(\frac{n-1}{10n}\right)a$ (d) $\frac{10a}{n}$

JEE Main-16.03.2021, Shift-I

Ans. (d) :

1 MSD of vernier callipers = a cm = 10a mm

n^{th} division of vernier scale coincide with $(n-1)^{th}$ division of the main scale

So, n × V.S.D. = (n − 1) × M.S.D.

@apna_pdf

$$1 \times \text{V.S.D} = \frac{(n-1)}{n}\text{M.S.D.}$$

Least count (LC) = 1 M.S.D. − 1 V.S.D.

$$= 1\text{MSD} - \left(\frac{n-1}{n}\right)\text{M.S.D.}$$

$$= \left[1 - \left(\frac{n-1}{n}\right)\right]\text{M.S.D.}$$

$$= \frac{1}{n}\text{MSD}$$

$$\text{Least count} = \frac{1}{n} \times 10a \text{ mm} \quad (\because\ 1 \text{ MSD} = 10a \text{ mm})$$

$$\text{LC} = \left(\frac{10a}{n}\right)\text{mm}$$

582. The vernier scale used for measurement has a positive zero error of 0.2 mm. If while taking a measurement, it was noted that '0' on the vernier scale lies between 8.5 cm and 8.6 cm, vernier coincidence is 6, then the correct value of measurement is ……… cm.

(a) 8.36 (b) 8.54

(c) 8.58 (d) 8.56

JEE Main-17.03.2021, Shift-I

Ans. (b) :

Positive zero error = 0.2mm = 0.02cm

Least count (LC) = 0.01cm

Main scale reading (MSR) = 8.5cm

Vernier scale reading (VSR) = 6

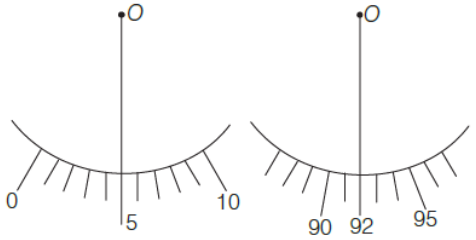
Correct value

$$= \text{MSR} + \text{VSR} \times (\text{LC}) - \text{positive zero error}$$

$$= 8.5 + 6 \times 0.01 - 0.02$$

$$= 8.54\text{cm}$$

583. Student A and student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the radius of the wire is 0.322 cm. The absolute value of the difference between the final circular scale readings observed by the students A and B is ……… . [Figure shows position of reference O when jaws of screw gauge are closed] Given, pitch = 0.1 cm.



Screw gauge (A) Screw gauge (B)

JEE Main-25.07.2021, Shift-I

Ans. (13) :

Actual value of radius = 0.322 cm

Pitch = 0.1 cm

Number of division = 100

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{No. of division}} = \frac{0.1}{100}$$

$$\text{LC} = 10^{-3}\text{cm}$$

$$\text{Positive error} = 5 \times 10^{-3}$$

For Student (A)

Actual reading = MSR + CSR + Positive error

$$0.322 = 0.300 + \text{CSR} + 5 \times 10^{-3}$$

$$(\text{CSR})_A = 0.022 - 0.005 = 0.017\text{cm}$$

For Student B

$$\text{Positive error} = 92 \times 10^{-3} = 0.092$$

Actual reading = MSR + CSR + positive error

$$0.322 = 200 + \text{CSR} + 0.092$$

$$(\text{CSR})_B = 0.030 \text{ cm}$$

$$\text{Difference} = (\text{CSR})_B - (\text{CSR})_A$$

$$= 0.030 - 0.017$$

$$= 0.013 \text{ cm}$$

$$\text{Division on circular scale} = \frac{0.013}{\text{LC}}$$

$$= \frac{0.013}{10^{-3}}$$

$$= 13$$

584. The diameter of a spherical bob is measured using a Vernier callipers. 9 divisions of the main scale, in the vernier calipers, are equal to 10 divisions of vernier scale. One main scale division is 1mm. The main scale reading is 10 mm and 8th division of vernier scale was found to coincide exactly with one of the main scale division. If the given vernier callipers has positive zero error of 0.04 cm, then the radius of the bob is ……… $\times 10^{-2}$ cm.

JEE Main-31.08.2021, Shift-II

Ans. (52) : Given that,

9 MSD = 10 VSD

$$1 \text{ VSD} = \frac{9}{10}\text{MSD}$$

and $1\text{MSD} = 1\text{mm}$

Least count (LC) = 1 MSD − 1 VSD

$$= 1\text{MSD} - \frac{9}{10}\text{ MSD}$$

$$= \frac{1}{10}\text{MSD}$$

$$= \frac{1}{10} \times 1\text{mm} \qquad (\because 1 \text{ MSD} = 1 \text{ mm})$$

@apna_pdf

$$LC = 0.1\,mm$$

Main scale reading (MSR) = 10 mm

VSR = 8

Positive zero error = 0.4

Actual diameter = MSR + VSR × (LC) − zero positive error

$d = 10 \times 8 \times 0.1 - 0.4$

$d = 10.4$ mm

$$\text{So, radius (r)} = \frac{d}{2} = \frac{10.4}{2} = 5.2\,mm$$

$$r = 52 \times 10^{-2}\,cm$$

585. A student is performing the experiment of resonance column. The diameter of the column tube is 6 cm. The frequency of the tuning fork is 504 Hz. Speed of the sound at the given temperature is 336 m/s. The zero of the meter scale coincides with the top end of the resonance column tube. The reading of the water level in the column when the first resonance occurs is

(a) 13 cm (b) 16.6 cm

(c) 18.4 cm (d) 14.8 cm

[JEE Mains- 2021, 25 Feb Shift-I]

Ans. (d) : Given.

f = 504 Hz

D = 6 cm

$V_s = 336$ m/s

e = 0.3 D

$$f = \frac{V}{\lambda} = \frac{V}{4(I+e)}$$

$$\because \lambda = 4(I + e)$$

$$\text{Now,} \quad 504 = \frac{336}{4(I+e)}$$

$$I + e = \frac{336}{4 \times 504}$$

$$I + e = \frac{2}{3} \times \frac{100}{4}$$

I + e = 16.6 cm

I + 0.3D = 16.6

I = 16.6 – 0.3 × 6

I = 16.6 – 1.8

I = 14.8 cm

586. In a screw gauge, 5th division the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation the reading on the main scale is 5 mm and the 20th division of the circular scale coincides with reference line calculate the true reading.

(a) 5.00 mm (b) 5.25 mm

(c) 5.15 mm (d) 5.20 mm

[JEE Mains- 2021, 26 Aug Shift-I]

Ans. (c) : $\text{Least count (LC)} = \frac{0.5}{50}$

= 0.01 mm

zero error = (MSR × LC)

= 5 × 0.01

= 0.05 mm

True reading = MSR + (CSR × LC) – zero error

= 5 + (20 × 0.01) – 0.05

= 5.15 mm

587. Assertion A- If in five complete rotations of the circular scale, the distance travelled on main scale of the screw gauge is 5 mm and there are 50 total divisions on circular scale, then least count is 0.001 cm.

Reason R- Least count

$$= \frac{\textbf{Pitch}}{\textbf{Total divisions on circular scale}}.$$

In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are correct and R is the correct explanation of A.

(b) Both A and R are correct and R is not the correct explanation of A.

(c) A is correct but R is not correct.

(d) A is not correct but R is correct.

[JEE Mains- 2021, 27 July Shift-I]

Ans. (d) :

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{Total division on circular scale}}$$

$$= \frac{1}{50}$$

= 0.02 mm

= 0.002 cm

Hence, the reason is correct but assertion is not correct.

588. The pitch of the screw gauge is 1 mm and there are 100 divisions on the circular scale. When nothing is put in between the jaws, the zero of the circular scale lies 8 divisions below the reference line. When a wire is placed between the jaws, the first linear scale division is clearly visible while 72nd division on circular scale coincides with the reference line. The radius of the wire is

(a) 1.64 mm (b) 0.82 mm

(c) 1.80 mm (d) 0.90 mm

[JEE Mains- 2021, 25 Feb Shift-I]

Ans. (b) : Given,

Pitch = 1 mm

$$\text{Least count (L.C)} = \frac{\text{pitch}}{\text{No. of divison on circular scale}}$$

$$= \frac{1}{100}$$

= 0.01 mm

@apna_pdf

Positive zero error $= 0 + 8 \times \text{L.C.}$

$= 8 \times 0.01$

$= 0.08$ mm

MSR = 1 mm

CSR = 72×L.C.

=72 × 0.01

= 0.72 mm

Diameter of final reading

= MSR + CSR – zero error

= 1+ 0.72 – 0.080 = 1.64 mm

The radius of wire $= \dfrac{1.64}{2}$ mm = 0.82 mm

589. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5mm and zero division of the circular scale coincides with 25 division above the reference level. If the screw gauge has a zero error of 0.004 cm. the correct diameter of the ball is_______

(a) 0.521 cm (b) 0.525 cm

(c) 0.529 cm (d) 0.053 cm

AP EAMCET-03.09.2021, Shift-II

Ans. (c) :

LC = 0.001 cm

MSR = 5 mm = 0.5 cm

25 division coincide with zero of circular scale division,

Diameter of ball = Calculated value + error

$= (\text{MSR}) + (\text{division} \times \text{LC}) + \text{error}$

$= 0.5 + (25 \times 0.001) + (0.004)$

$= 0.5 + 0.025 + 0.004$

$= 0.529\text{cm}$

590. A screw gauge gives the following readings when used to measure the diameter of a wire

Main scale reading : 0 mm

Circular scale reading: 52 divisions

Given that, 1mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is

(a) 0.52 cm (b) 0.026 cm

(c) 0.26 cm (d) 0.052 cm

[NEET 2021]

Ans. (d) : Circular scale reading (CSR) = 52

Pitch = 1 mm

No. of division on circular scale = 100

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{No. of division on circular scale}}$$

$$\text{Least Count (LC)} = \frac{1\text{mm}}{100} = 0.01\text{mm}$$

Diameter of the wire $= \text{CSR} \times \text{LC}$

$= 52 \times 0.01\text{mm} = 0.52\,\text{mm}$

$= 0.052\,\text{cm}$

591. In an experiment the angles are required to be measured using an instrument in which 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half a degree (=0.5°), then the least count of the instrument is

(a) half minute (b) one degree

(c) half degree (d) one minute

TS-EAMCET.14.09.2020, Shift-2

Ans. (d) : According to the question,

29 main scale division (MSD) = 30 vernier scale division (VSD)

$\Rightarrow$ 29 MSD = 30 VSD

$$1 \text{ VSD} = \frac{29}{30} \times 1 \text{ MSD}$$

Least count of the instrument $= 1\text{MSD} - 1\text{VSD}$

$$= 1\text{MSD} - \frac{29}{30}\text{MSD}$$

$$= \frac{1}{30}\text{MSD}$$

$$= \frac{1}{30} \times 0.50 \qquad \begin{bmatrix} \text{MSD} = 0.5^\circ \\ 0.5^\circ \times 60 = 30\,\text{min} \end{bmatrix}$$

$$= \frac{1}{30} \times 30\,\text{min}$$

= One minute.

592. The least count of the main scale of a vernier callipers is 1 mm. Its Vernier scale is divided into 10th division and coincide with 9th division of the main scale. When jaws are touching each other, the 7th division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of a cylinder the zero of the vernier scale lies between 3.1 cm and 3.2 cm and 4th VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division)

(a) 3.2 cm (b) 2.99 cm

(c) 3.07 cm (d) 3.21 cm

[JEE Mains- 2020, 2 Sep Shift-I]

Ans. (c) : Given,

The scale division (MSD) = 1 mm

10 Vernier scale division = 9 main scale division

One Vernier scale division (VSD) $= \dfrac{9}{10}$ MSD = 0.9 mm

So, the least count of instrument is

L.C. = 1 MSD – 1 VSD

LC = 1 MSD – $\dfrac{9}{10}$ MSD

LC = $\dfrac{1}{10}$ MSD $\Rightarrow$ LC = 0.1 mm

@apna_pdf

The zero of vernier scale lies to the right of the main scale, so the error is positive.

zero error = 7 × LC

= 7 × 0.01 cm = 0.07 cm

Observed value = MSR + VSR × LC – zero error

Main scale reading (MSR) = 3.1 cm

Vernier scale reading (VSR) = 4 division

Observed value = 3.1 + 4 × 0.01 – 0.07

= 3.14 – 0.07 = 3.07 cm

Therefore, the length of cylinder is 3.07 cm

593. Using screw gauge of pitch 0.1 cm and 50 divisions on its circular scale, the thickness of an object is measured. It should correctly be recorded as

(a) 2.121 cm (b) 2.124 cm

(c) 2.125 cm (d) 2.123 cm

[JEE Mains- 2020, 3 Sep Shift-I]

Ans. (b) : Let t be the thickness of the object

So, t = MSR + (n×LC)

Where, n = No. of circular scale division lie over reference line

MSR = Main scale reading

LC = Least count of screw gauge

Least count of gauge is

$$(\mathrm{LC}) = \frac{\text{Pitch}}{\text{Number of division on circular scale}}$$

$$= \frac{0.1}{50} = 0.002 \text{ cm}$$

When we multiply by division number it must be even because LC is 0.02 so any measurement will be an integral multiple of LC.

Therefore, the digit at the third decimal place will be an even number.

So, the answer is 2.124 cm.

594. A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved and the least count of the screw gauge, are respectively

(a) negative, 2 µm (b) positive, 10 µm

(c) positive, 0.1 mm (d) positive, 0.1 µm

[JEE Mains- 2020, 6 Sep Shift-I]

Ans. (b) : Given,

Number of division on circular scale of screw gauge = 50 pitch = 0.5 mm

Least count of screw gauge

$$(\mathrm{LC}) = \frac{\text{Pitch}}{\text{No. of division on circular scale}}$$

$$= \frac{0.5}{50} = \text{mm} = 1\times10^{-5}\text{ m} = 10\ \mu\text{m}$$

The nature is positive and least count is 10 µm

595. A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings; 5.50 mm, 5.55 mm, 5.45 mm and 5.65 mm. The average of these four readings is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should be therefore recorded as

(a) (5.5375 ± 0.0739) mm

(b) (5.5375 ± 0.0740) mm

(c) (5.538 ± 0.074) mm

(d) (5.54 ± 0.07) mm

[JEE Mains- 2020, 6 Sep Shift-II]

Ans. (d) : Four reading of vernier calipers are 5.50 mm, 5.55 mm, 5.45 mm, 5.65 mm.

The average of these four readings

$$= \frac{5.5+5.55+5.45+5.65}{4}$$

= 5.5375 mm

Standard deviation of the data is 0.07395

The significant rule says that reading should have the same significant figure as that of the reading given.

It we do round off 5.5375 then we will get 5.54 as 7>5

If we do round off 0.07395 then we will get 0.07 as 3 < 5

So, Average diameter will be

(5.54 ± 0.07)m as 0.07 mm is standard diviation of the data.

596. If the screw on a screw gauge is given six rotations, it moves by 3 mm on the main scale. If there are 50 divisions on the circular scale, the least count of the screw gauge is

(a) 0.001 cm (b) 0.01 cm

(c) 0.02 cm (d) 0.001 cm

[JEE Mains- 2020, 9 Jan Shift-I]

Ans. (a) : Given,

On six rotation, readings of main scale changed by 3 mm

No. of division on circular scale = 50

$$\text{Pitch} = \frac{\text{Distance moved by screw}}{\text{Number of rotation}}$$

$$= \frac{3\text{mm}}{6} = 0.5 \text{ mm}$$

Least count of screw gauge

$$(\mathrm{LC}) = \frac{\text{Pitch}}{\text{No. of circular scale division}}$$

$$= \frac{0.5\text{mm}}{50} = 0.01 \text{ mm} = 0.001 \text{ cm}$$

597. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is

(a) 0.25 mm (b) 0.5 mm

(c) 1.0 mm (d) 0.01 mm

[NEET (Sep.) 2020]

@apna_pdf

Ans. (b) :
Least Count = 0.01 mm
No. of divisions = 50
We know,

$$\text{Least count} = \frac{\text{Pitch}}{\text{No.of divisions on circular scale}}$$

Pitch = least count × No. of divisions on circular scale

$$= 0.01 \times 50 = 0.5\text{mm}$$

598. The least count of the main scale of a screw gauge is 1 mm. The minimum number of divisions on its circular scale required to measure 5μm diameter of a wire is

(a) 50 (b) 200
(c) 500 (d) 100

JEE Main-12.01.2019, Shift-I

Ans. (b) : Least count of the main scale of screw Gauge = $1\text{mm} = 10^{-3}\text{ m}$

Pitch of screw gauge = 10^{-3}m

LC = $5\mu\text{m} = 5\times10^{-6}$m

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{No. of divisions on circular scale }(x)}$$

$$5\times10^{-6} = \frac{10^{-3}}{x}$$

$$x = \frac{10^{-3}}{5\times10^{-6}} = 0.2\times10^{3}$$

$$x = 200$$

599. The pitch and the number of divisions, on the circular scale for a given screw gauge are 0.5 mm and 100, respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 divisions below the mean line. The readings of the main scale and the circular scale for a thin sheet are 5.5 mm and 48 respectively, the thickness of this sheet is

(a) 5.950 mm (b) 5.725 mm
(c) 5.755 mm (d) 5.740 mm

JEE Main-09.01.2019, Shift-II

Ans. (b) : Least count of pitch = 0.5 mm
No. of divisions = 100

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{No.of divisions}}$$

$$LC = \frac{0.5}{100}$$

$$LC = 5\times10^{-3}\text{mm}$$

Positive error = 3 × Least count

$$= 3\times5\times10^{-3}$$

$$= 0.015\text{mm}$$

Main scale reading (MSR) = 5.5mm
Circular scale reading (CSR) = 48
So, thickness of sheet = MSR + CSR × LC − (positive error)

$$= 5.5 + 48\times5\times10^{-3} - 0.015$$

$$= 5.5 + 0.24 - 0.015$$

$$= 5.725 \text{ mm}$$

600. N divisions on the main scale of a vernier calipers coincide with (N + 1) division of the vernier scale. If each division of main scale is a units, then the least count of the calipers is :

(a) $\frac{a}{N}$ (b) a

(c) $\frac{a}{N+1}$ (d) $\frac{Na}{N+1}$

AP EAMCET (21.04.2019) Shift-II

Ans. (c) : Given, N MSD = (N +1) VSD

$$\left(\frac{N}{N+1}\right).\text{MSD} = 1\text{ VSD}$$

$$1\text{MSD} = a$$

$$1\text{VSD} = \frac{N}{N+1}\times a$$

Least Count = 1 MSD – 1 VSD

$$= a - \frac{Na}{N+1} = \frac{Na + a - Na}{N+1}$$

$$LC = \frac{a}{N+1}$$

601. The main scale of a vernier calliper has *n* divisions/cm. *n* divisions of the Vernier scale coincide with (*n* -1) divisions of main scale. The least count of the vernier callipers is

(a) $\frac{1}{(n+1)(n-1)}$cm (b) $\frac{1}{n}$cm

(c) $\frac{1}{n^2}$cm (d) $\frac{1}{n(n+1)}$cm

[NEET (Odisha) 2019]

Ans. (c) :
Least Count (LC) = 1MSD − 1VSD

$$n(\text{VSD}) = (n-1)\text{MSD}$$

$$\text{VSD} = \frac{(n-1)}{n}\text{MSD}$$

LC = MSD – VSD
Put the value of VSD in equation

$$LC = 1\text{MSD} - \frac{(n-1)}{n}\text{MSD}$$

$$LC = \frac{1}{n}\text{MSD}$$

Since, $n(\text{MSD}) = 1\text{cm}$

$$\text{MSD} = \frac{1}{n}\text{cm}$$

Hence, $LC = \frac{1}{n^2}\text{cm}$

602. The length is measured using a vernier system whose main scale is 30 cm long with 600 divisions. If 19 divisions of the main scale coincide with 20 divisions of the vernier scale, then its least count is

@apna_pdf

(a) 0.25cm (b) 0.025cm
(c) 0.25mm (d) 0.025mm
(e) 0.0025mm

Kerala CEE -2018

Ans. (d) : Least count =1MSD – 1VSD

$$\text{MSD} = \frac{\text{Length of Main scale}}{\text{No. of division}}$$

$$= \frac{30}{600}\text{cm} = \frac{30\times10^{-2}}{600}\text{m} = 5\times10^{-4}\text{m}$$

$$1\text{ VSD} = \frac{19}{20}\times\text{MSD (Given)} = \frac{19}{20}\times5\times10^{-4} = 4.75\times10^{-4}$$

Least count = 1MSD – 1VSD

$\therefore$ Least count = $(5 - 4.75)\times10^{-4}$ m = 0.025 mm

603. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment, distances are measured by

(a) a vernier scale provided on the microscope
(b) a standard laboratory scale
(c) a meter scale provided on the microscope
(d) a screw gauge provided on the microscope

[AIEEE 2008]

Ans. (a) : To find the refraction index of glass using a travelling microscope, a Vernier scale is provided on the microscope is used

604. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of aluminum. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that the zero of the main scale is barely visible.

What is the thickness of the sheet, if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line?

(a) 0.75 mm (b) 0.80 mm
(c) 0.70 mm (d) 0.50 mm

[JEE Main 2016]

Ans. (b) : Zero error = –5 division of circular scale

$$1\text{ division of circular scale } = \frac{0.5}{50} = 0.01\text{ mm}$$

$\therefore$ zero error = -5×10^{-2} = – 0.05 mm

zero correction = +0.05 mm

Reading = 0.5 + 25×0.01 + 0.05= 0.80 mm

605. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?

(a) A meter scale
(b) A vernier caliper where the 10 divisions in vernier scale matches with 9 divisions in main scale and main scale has 10 divisions in 1 cm
(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm
(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm

[JEE Main 2014]

Ans. (b) : $\because$ Measured value is 3.50 cm

$\therefore$ Least count of measuring instrument = 0.01 cm

For vernier Calliper,

L.C = 1 MSD – 1 VSD = 1 MSD –

$$\left(\frac{9}{10}\right)\text{MSD} = \frac{1}{10}\text{MSD} = \frac{1}{10}\times0.1\text{ cm} = 0.01\text{ cm}$$

606. A screw gauge gives the following reading when used to measure the diameter of a wire. Main scale reading 0 mm circular scale reading 52 divisions Given that 1 mm on main scale corresponds to 100 divisions of the circular scale. The diameter of wire from the above data is

(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

[AIEEE 2011]

Ans. (a) : Given,

Pitch of the screw gauge, P = 1 mm

Number of circular division, n = 100

$$\text{Least count }(\text{LC}) = \frac{\text{Pitch}}{\text{Division}} = \frac{1}{100} = 0.001\text{ cm}$$

Diameter of the wire

= MSR + (CSR × LC)

=0+ (52 × 0.001 cm) = 0.052 cm

607. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of –0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 3.5. The diameter of the wire is

(a) 3.32 mm (b) 3.72 mm
(c) 3.67 mm (d) 3.38 mm

[AIEEE 2008]

Ans. (d) :

$$\text{Least count of screw gauge }(\text{LC}) = \frac{0.5}{50}\text{mm} = 0.01\text{ mm}$$

$\therefore$ Reading = [MSR + CSR × LC] – [zero error]

= [3+35×0.01] – (–0.03) = 3.38 mm

608. In a vernier callipers N divisions of vernier scale coincide with N −1 divisions of main scale (in which length of one division is 1 mm). The least count of the instrument should be

(a) N (b) N−1
(c) $\frac{1}{10\text{N}}$ (d) $\frac{1}{(\text{N}-1)}$

[AIPMT 1994]

Ans. (c) :

According to the question,

$$\text{N}\times\text{VSD} = (\text{N}-1)\text{ MSD}$$

$$\text{VSD} = \frac{(\text{N}-1)}{\text{N}}\text{MSD}$$

@apna_pdf

$\because \quad LC = 1MSD - 1VSD$

$$= 1MSD - \frac{(N-1)}{N}MSD = \frac{1}{N}MSD$$

Since, $1MSD = 1mm = 0.1cm$

Hence, $LC = \frac{1}{10N}$

609. In an experiment, the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half a degree (= 0.5°), then the least count of the instrument is

(a) one minute (b) half minute

(c) one degree (d) half degree

AIEEE 2009

Ans. (a) : Given that, the 29 divisions of the main sale (MSD) exactly coincide with the 30 divisions of VSD

$\because \quad 29 \text{ M.S.D} = 30 \text{ V.S.D}$

$$1 \text{ V.S.D} = \frac{29}{30} \text{M.S.D}$$

Least count (L.C) = 1MSD − 1VSD

$\therefore \quad LC = 1MSD - \frac{29}{30}MSD$

$$LC = \frac{1}{30}MSD$$

$\because$ Smallest division of the main scale (MSD) is half degree (0.5)

$$1° = 60 \text{ minute}$$

$$0.5° = 30 \text{ minute}$$

So, Least count (LC) $= \frac{1}{30} \times 30$ minute

L.C. = 1 minute

610. A spectrometer gives the following reading when used to measure the angle of a prism. Main scale reading : 58.5 degree Vernier scale reading : 09 divisions. Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data is

(a) 58.59 degree (b) 58.77 degree

(c) 58.65 degree (d) 59 degree

AIEEE 2012

Ans. (c) : Given that, $1MSD = 0.5°$

Main scale reading (MSR) $= 58.5°$

Vernier scale reading (VSR) $= 09°C$

$\because \quad 30\,VSD = 29\,MSD$

$$1VSD = \frac{29}{30} MSD$$

Least count (L.C.) = 1 MSD − 1VSD

$$= 1 \text{ MSD} - \frac{29}{30} \text{ MSD}$$

$$= \frac{1}{30} \text{ MSD}$$

So, least count $LC = \frac{1}{30} \times 0.5°$

$$LC = \left(\frac{1}{60}\right)^{\circ}$$

Angle of the prism = M.S.R + V.S.R × Least count (LC)

$$= 58.5 + 9 \times \frac{1}{60} \text{ degree}$$

$$= 58.5 + 0.15 \text{ degree} = 58.65 \text{ degree}$$

611. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?

(a) A meter scale

(b) A vernier calliper where the 10 divisions in vernier scale matches with 9 divisions in main scale and main scale has 10 divisions in 1 cm

(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm

(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm

JEE Main 2014

Ans. (b) : A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm.

$\Rightarrow \quad 1cm = 10\,MSD$

$$1MSD = \frac{1}{10}cm$$

$$10 \text{ VSD} = 9 \text{ MSD}$$

$$1VSD = \frac{9}{10} \text{ MSD}$$

Least count (LC) = 1 MSD − 1VSD

$$= 1 \text{ MSD} - \frac{9}{10} \text{MSD}$$

$$LC = \frac{1}{10}MSD$$

So, $\quad LC = \frac{1}{10} \times \frac{1}{10}cm \quad \left(\because 1MSD = \frac{1}{10}cm\right)$

$$LC = 0.01cm$$

612. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90s, 91s, 92s and 95s. If the minimum division in the measuring clock is 1s, then the reported mean time should be

(a) (92 ± 2)s (b) (92 ± 5)s

(c) (92 ± 1.8)s (d) (92 ± 3)s

JEE Main 2016

Ans. (a) :

Data set is 90s, 91s, 92s and 95s

Mean of data $= \frac{90+91+92+95}{4}s$

$$\text{Mean} = \frac{368}{4}s = 92\,s$$

Error mean $= \frac{|M-M_1|+|M-M_2|+|M-M_3|+|M-M_4|}{4}$

@apna_pdf

$$=\frac{|(92-90)|+|(92-91)|+|(92-92)|+|(92-95)|}{4}$$

$$=\frac{2+1+0+3}{4}=\frac{6}{7}=1.5\,\text{s}$$

Since minimum division in the measuring clock is 1s.
So, error mean = 2 sec.

$\therefore$ Reported mean time should be (92 ± 2) s

613. In a slide calliper, (m + 1) number of vernier divisions is equal to m number of smallest main scale divisions. If d unit is the magnitude of the smallest main scale division, then the magnitude of the vernier constant is

(a) d/(m + 1) unit (b) d/m unit
(c) md/(m + 1) unit (d) (m + 1)d/m unit

WB JEE 2012

Ans. (a) : (m + 1) number of vernier divisions is equal to **m** number of smallest main scale divisions.

(m + 1) VSD = (m) MSD

$$1\text{ VSD}=\left(\frac{m}{m+1}\right)\text{MSD}$$

Least count (LC) = 1 MSD - 1 VSD

$$=1\text{M.S.D}-\left(\frac{m}{m+1}\right)\text{MSD}$$

$$=\left(1-\frac{m}{m+1}\right)\text{MSD}\quad=\frac{1}{(m+1)}\text{M.S.D}$$

$$\text{L.C.}=\frac{d}{(m+1)}\text{unit}\quad(\because\ 1\text{MSD} = \text{'d' unit})$$

614. Pitch of a screw gauze instrument is 0.5 mm and its circular scale is divided into 100 divisions. The least count of the instrument will be

(a) 0.005 mm (b) 0.05 mm
(c) 0.0005 mm (d) 0.50 mm

WB JEE-2007

Ans. (a) : Given that, Pitch of screw gauge = 0.5 mm

Number of circular division = 100

$$\text{Least count (LC)}=\frac{\text{Pitch}}{\text{No. of circular division}}=\frac{0.5}{100}\text{mm}$$

$$\text{L.C.}=0.005\text{mm}$$

615. The height of a man is measured by a metre scale having graduations in centimeter only and the height turns out to be 170 cm. The scientific method for reporting the measurement is

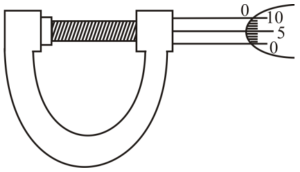
(a) 170×10^0 cm (b) 1.700 cm
(c) 170 cm (d) 1.70×10^2 cm

AMU-2014

Ans. (d) :

The scientific method for reporting the measurement is $1.70\times 10^2\text{cm}$

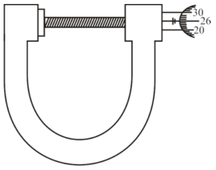
616. The circular division of shown screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball is



(a) 2.25 mm (b) 2.20 mm
(c) 1.20 mm (d) 1.25 mm

Manipal UGET-2014

Ans. (c) :



$$\text{Least Count (LC)}=\frac{0.5}{50}=0.01\text{mm}$$

$$\text{Zero error}=5\times\frac{0.5}{50}=0.05\text{mm}$$

$$\text{Circular scale reading}=25\times 0.01=0.25\text{mm}$$

Main scale reading = 2 × 0.5 = 1 mm

Actual measurement = MSR + CSR – Zero error

$$\text{Actual measurement}=2\times 0.5\text{ mm}+25\times\frac{0.5}{50}-0.05\text{mm}$$

$$=1\text{mm}+0.25\text{mm}-0.05\text{mm}$$

$$=1.20\text{mm}$$

617. Which of the following is most accurate?

(a) A screw gauge of least count 0.001 mm
(b) A screw gauge having pitch 1 mm and 50 divisions on circular scale
(c) A vernier callipers of least count 0.01 mm
(d) Vernier callipers having 20 divisions on the sliding scale (vernier scale) coinciding 19 divisions on the main millimetre scale.

BITSAT-2009, 2007

Ans. (a) : By option (a),

Least count of screw gauge = 0.001 mm

By option (b),

$$\text{Least count}(\text{L.C})=\frac{\text{Pitch}}{\text{Number of circular disivion}}$$

$$=\frac{1}{50}=0.02\text{mm}$$

By option (c),

Least count of Vernier Callipers = 0.01 mm

By option (d),

Least count = Main scale division – Vernier scale division $=1-\dfrac{19}{20}$ $\left[\begin{matrix}20\text{V.S.D}=19\text{M.S.D}\\ 1\text{V.S.D}=\dfrac{19}{20}\text{M.S.D}\end{matrix}\right]$

$$=\frac{1}{20}=0.05\text{ mm}$$

Hence, the most accurate is 0.001 mm.

@apna_pdf

618. The pitch and the number of circular scale divisions in a screw gauge with least count 0.02 mm are respectively

(a) 1 mm and 100 (b) 0.5 mm and 50
(c) 1 mm and 50 (d) 0.5 mm and 100
(e) 1 mm and 200

Kerala CEE- 2014

Ans. (c) : We know that,
Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{Number of circular scale division}}$$

$$0.02 = \frac{\text{Pitch}}{\text{Number of circular scale division}}$$

$$\frac{1}{50} = \frac{\text{Pitch}}{\text{Number of circular scale division}}$$

So, pitch is 1 mm and number of circular scale division is 50.

619. In a Vernier Callipers, there are 20 divisions on the vernier scale that are equal to 19 divisions on the main scale. What is the least count of the instrument? (one main scale division is 1 mm)

(a) 0.01 cm (b) 0.05 cm
(c) 0.005 cm (d) 0.5 cm

SCRA-2015, 2012

Ans. (c) : Formula, Least count (LC) = 1 MSD – 1 VSD
Given, 20 VSD = 19 MSD
Where, VSD = Vernier scale division
MSD = Main scale division
LC = Least count

$$1\text{ VSD} = \frac{19}{20}\text{MSD}$$

$$\therefore \quad \text{LC} = 1\text{ MSD} - \frac{19}{20}\text{MSD}$$

$$\text{LC} = \frac{1}{20}\text{ MSD} \quad (\because 1\text{MSD} = 0.1\text{ cm})$$

$$= 0.05 \times 0.1$$

$$\text{LC} = 0.005\text{ cm}$$

620. The pitch of a screw gauge is 0.5 mm. Its head scale contains 50 divisions The least count of the screw gauge is

(a) 0.0001 cm (b) 0.0025 cm
(c) 0.01 cm (d) 0.001 cm

SCRA-2013

Ans. (d) : $\text{LC} = \dfrac{\text{Pitch of screw}}{\text{20 of head serew divisions}}$

$$\text{LC} = \frac{0.5\text{ mm}}{50} = \frac{0.1\text{mm}}{10}$$

$$\text{LC} = 0.1 \times 0.1 = 0.01\text{mm} = 0.001\text{cm}.$$

621. Each division on the main scale is 1 mm. Which one of the following vernier scales will give vernier constant equal to 0.01 mm?

(a) 9 mm divided by 10 divisions
(b) 95 mm divided by 100 divisions
(c) 99 mm divided by 100 divisions
(d) 9 mm divided by 100 divisions

SCRA-2010

Ans. (c) : Least count = 1 MSD – 1 VSD

$$1\text{ VSD} = 1\text{ MSD} - \text{LC}$$

$$= 1\text{ mm} - 0.01\text{ mm} = 0.99\text{ mm}$$

∴ 1 VSD = 99 mm divided by 100 divisions.

622. Smallest division on the main scale of given vernier callipers is 0.5 mm. Vernier scale has 25 divisions and these coincide with 24 main scale divisions. The least count of vernier callipers is

(a) 0.001 cm (b) 0.002 cm
(c) 0.01 cm (d) 0.02 cm

J&K-CET-2015

Ans. (b) : Least count = 1MSD – 1 VSD
Given, 24 MSD = 25 VSD, 1 MSD = 0.5 mm

$$1\text{ VSD} = \frac{24}{25}\text{MSD}$$

$$\therefore \ \text{Least count} = 1\text{ MSD} - 1\text{ VSD} = 1\text{ MSD} - \frac{24}{25}\text{MSD}$$

$$= \frac{1}{25}\text{MSD} = \frac{1}{25} \times 0.5 = 0.02\text{mm}$$

$$\text{LC} = 0.002\text{ cm}.$$

623. The 'rad' is the correct unit used to report the measurement of

(a) the ability of a beam of gamma ray photons to produce ions in a target
(b) the energy delivered by radiation to a target
(c) the biological effect of radiation
(d) the rate of decay of a radioactive source

AIEEE 2006

Ans. (c) : Radiation is the emission or transmission of energy in the form of waves or particles through space or a material medium. One rad is equal approximately to the absorbed dose delivered when soft tissue is exposed to one roentgen of medium-voltage radiation. Thus, this is the biological effect of radiation.

624. A spherometer has 20 threads per cm. Its circular scale has 100 divisions. The least count of the sphere is

(a) 5μm (b) 50μm (c) 0.5μm (d) 0.05μm

SRMJEE - 2015

Ans. (a) : Here, for 20 threads per cm pitch = 0.05cm

$$\text{L.C.} = \frac{\text{Pitch}}{\text{No. of division}} = \frac{0.05}{100}\text{cm} = 5 \times 10^{-6}\text{m} = 5\ \mu\text{m}$$

625. In Poiseuille's method of determination of coefficient of viscosity, the physical quantity that requires greater accuracy in measurement is :

(a) pressure difference
(b) volume of the liquid collected
(c) length of capillary tube
(d) inner radius of capillary tube

AP EAMCET(Medical)-2001

Ans. (d) : Viscosity $(\eta) = \dfrac{\pi P r^4}{8VI}$

Since, inner radius of the capillary tube appears with a 4^{th} power in the equation. Therefore, inner radius must be measured with high accuracy.

@apna_pdf

02. Motion in One Dimensions

(a) Distance and Displacement

1. **A body of mass 2kg is initially at rest. It starts moving unidirectionally under the influence of a source of constant power P. Its displacement in 4s is $\frac{1}{3}\alpha^2\sqrt{P}$m. The value of α will be**

JEE Main-30.01.2023, Shift-II

Ans. (4) : Given, m = 2 kg and time (t) = 4s

We know,

Relation between displacement and time

$$x=\frac{2}{3}\sqrt{\frac{2P}{m}}t^{3/2}$$

$$x=\frac{2}{3}\sqrt{\frac{2P}{2}}.4^{3/2}$$

$$x=\frac{1}{3}\times16\sqrt{P}$$

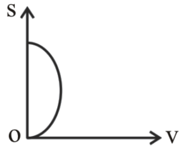
Then,

$$\alpha^2=16\Rightarrow\alpha=4$$

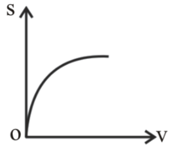
The value of α will be 4.

2. **An object is moving with a uniform acceleration which is parallel to its instantaneous direction of motion. The displacement (s) - velocity (v) graph of this object is ______**

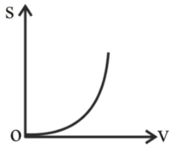
(a)



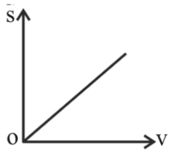
(b)



(c)



(d)



AP EAMCET-20.08.2021, Shift-II
SCRA-1998
DCE-2000
AIIMS-2003

Ans. (c) :

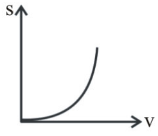
From Newton's third equation of motion,

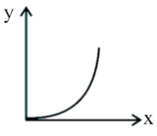
$$v^2-u^2=2as$$

$$v^2=2as \qquad [\because u=0]$$

We know,

Parabola equation, $x^2=2ay$





3. **The relation between time t and distance x is t =ax^2 + bx, where a and b are constants. The acceleration is**

(a) $-2\,abv^2$
(b) $2\,bv^3$
(c) $-2\,av^3$
(d) $2\,av^2$

MP PET-2012
BCECE-2006
AIEEE-2005
NCERT-1982

Ans. (c) : Let the acceleration be A.

$$\Rightarrow \quad t=ax^2+bx \qquad \ldots(i)$$

On differentiating the above equation with respect to t. Then,

$$\frac{d}{dt}(t)=\frac{d}{dt}(ax^2)+\frac{d}{dt}(bx)$$

$$1=2ax\frac{dx}{dt}+b\frac{dx}{dt}$$

$$1=\frac{dx}{dt}(2ax+b)$$

$$v=\frac{dx}{dt}=\frac{1}{(2ax+b)} \qquad \ldots(ii)$$

Again differentiating the equation number (ii) w.r.t. t

$$\frac{d^2x}{dt^2}=\frac{(2ax+b)\frac{d}{dt}(1)-1.\frac{d}{dt}(2ax+b)}{(2ax+b)^2}$$

$$\frac{d^2x}{dt^2}=\frac{-2a\frac{dx}{dt}}{(2ax+b)^2}$$

$$\because \quad v=\frac{dx}{dt}$$

$$\therefore \quad \frac{d^2x}{dt^2}=\frac{-2av}{(2ax+b)^2} \qquad \ldots(iii)$$

From equation no. (ii)

$$v=\frac{1}{(2ax+b)}$$

$$\text{Acceleration }=\frac{d^2x}{dt^2}=-2av\times\frac{1}{(2ax+b)^2}$$

Acceleration = $-2av \times v^2$

Acceleration = $-2av^3$

4. **A car moving with a speed of 40 km/h can be stopped after 2 m by applying brakes. If the same car is moving with a speed of 80 km/h, what is the minimum stopping distance?**

(a) 8 m (b) 2 m (c) 4 m (d) 3 m

AIEEE-2003, 2004
JIPMER-2001, 2002
AFMC-2000
AIPMT-1998

@apna_pdf

Ans. (a) :
For first case :

$$u = 40 \text{ km/h}$$
$$= \left(40\times\frac{5}{18}\right) \text{m/s}$$

For third equation of motion we have,

$$v^2 = u^2 + 2as$$
$$0 = \left(40\times\frac{5}{18}\right)^2 + 2a(2)$$
$$0 = \left(\frac{200}{18}\right)^2 + 4a$$
$$a = -\frac{1}{4}\left(\frac{100}{9}\right)^2 \quad ....(i)$$

For second case :-

$$u = 80 \text{ km/h}$$
$$u = \left(80\times\frac{5}{18}\right) \text{m/s}$$
$$v^2 = u^2 + 2as$$
$$0 = \left(80\times\frac{5}{18}\right)^2 + 2\times a\times s$$
$$2as = -\left(\frac{200}{9}\right)^2 \quad \_\_\_(ii)$$

Putting the value of 'a' in equation (ii)

$$-2\times\frac{1}{4}\times\left(\frac{100}{9}\right)^2\times s = -\left(\frac{200}{9}\right)^2$$
$$\frac{2}{4}\times\frac{100}{9}\times\frac{100}{9}\times s = \left(\frac{200}{9}\right)^2$$
$$\frac{s}{2} = 2\times 2$$
$$s = 2\times 2\times 2$$

Distance, s = 8 m

5. A particle moves along a straight line OX. At a time t (in seconds) the distance x (in meters) of the particle from O is given by

$$x = 40 + 12t - t^3$$

How long would the particle travel before coming to rest?

(a) 24 m
(b) 40 m
(c) 56 m
(d) 16 m

WE JEE-2012
JCECE-2007
AFMC-2006

Ans. (c) : Given that,
Distance $x = 40 + 12t - t^3$

$$\therefore \quad v = \frac{dx}{dt}$$
$$v = \frac{d}{dt}\left(40 + 12t - t^3\right)$$
$$v = 12 - 3t^2$$

Final velocity of the particle is zero (v = 0)

So, $\quad 12 - 3t^2 = 0$

$$t^2 = \frac{12}{3}$$
$$t = \sqrt{4}$$
$$t = 2\text{sec.}$$

Distance covered by the particle before coming to rest is

$$x = 40 + 12t - t^3$$
$$= 40 + 12\times 2 - 2^3$$
$$= 64 - 8$$
$$= 56 \text{ m}$$

6. A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10s is S_1 and that covered in the first 20 s is S_2, then

(a) $s_2 = 2s_1$
(b) $s_2 = 3s_1$
(c) $s_2 = 4s_1$
(d) $s_2 = s_1$

KCET-2012
MP PET-2011
AIPMT 2009

Ans. (c): Particle starts motion from rest, u = 0
Let, acceleration = a m/s^2, time t_1 = 10 sec
velocity after 10 second = v_1 m/s

So, $\quad v_1 = u + at_1$

$$v_1 = 0 + a\times 10$$
$$v_1 = 10\,a \text{ m/s}$$

And $\quad v_1^2 = u^2 + 2as_1$

$$(10a)^2 = 0 + 2as_1$$
$$s_1 = \frac{100a^2}{2a} = 50a$$

Velocity after t_2 = 20 second

$$v_2 = u + at_2$$
$$v_2 = 0 + a\times 20$$
$$v_2 = 20\,a$$

And $\quad v_2^2 = u^2 + 2as_2$

$$(20a)^2 = 0 + 2as_2$$
$$s_2 = s_1 = \frac{100a^2}{2a} = 50a$$

So, $\quad \frac{s_1}{s_2} = \frac{50a}{200a}$

$$\frac{s_1}{s_2} = \frac{1}{4}$$
$$s_2 = 4s_1$$

7. A particle located at x = 0, starts moving along the positive x-direction with a velocity v that varies as $v = \alpha\sqrt{x}$ where α is dimensionless constant. The displacement of the particle varies with time as

(a) t^3
(b) t^2
(c) t
(d) $t^{1/2}$

AMU-2015
UPSEE-2010
AIEEE-2006

@apna_pdf

Ans. (b) : Given,

$v = \alpha\sqrt{x}$ (velocity in x-direction)

Differentiating w.r.t time,

$$\frac{dx}{dt} = \alpha\sqrt{x}$$

$$\int_0^x \frac{dx}{\sqrt{x}} = \alpha\int_0^t dt$$

$$\left[2\sqrt{x}\right]_0^x = \alpha\left[t\right]_0^t$$

$$x = \frac{\alpha^2}{4}t^2$$

Hence, $x \propto t^2$ $\left[\frac{\alpha^2}{4} = \text{constant}\right]$

8. **The displacement of particle is given by**

$$\mathbf{x = a_0 + \frac{a_1 t}{2} - \frac{a_2 t^2}{3}}$$

What is its acceleration?

(a) $\frac{2a_2}{3}$ (b) $-\frac{2a_2}{3}$

(c) a_2 (d) zero

UPSEE - 2006
JIPMER-2006

Ans. (b) : Given that,

$$x = a_0 + \frac{a_1 t}{2} - \frac{a_2 t^2}{3}$$

$$v = \frac{dx}{dt} = 0 + \frac{a_1}{2} - \frac{2a_2 t}{3}$$

$$a = \frac{dv}{dt} = -\frac{2a_2}{3}$$

$$\boxed{\therefore\ a = \frac{-2a_2}{3}}$$

9. **A person moves 30 m north and then 20 m towards east and finally $30\sqrt{2}$ m in south-west direction. The displacement of the person from the origin will be**

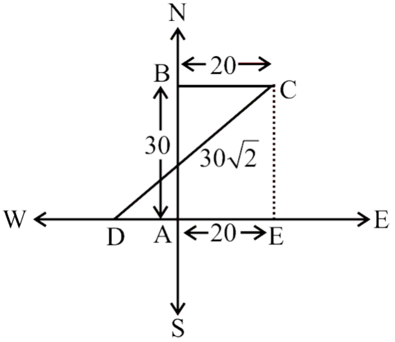
(a) 10 m along north (b) 10 m along south

(c) 10 m along west (d) zero

TS-EAMCET-11.09.2020, Shift-I
J&K CET- 2004

Ans. (c) : The person starts from A-

Then, he moves to B and then to C and finally to D.



In ΔDEC,

$$CD^2 = ED^2 + CE^2$$

$$ED^2 = (30\sqrt{2})^2 - (30)^2$$

$$ED^2 = 1800 - 900$$

$$ED^2 = 900$$

$$ED = 30\text{m}$$

∴ The displacement of the person from the origin will be

$$AD = DE - AE = 30 - 20 = 10 \text{ m}$$

The displacement of the person from the origin is 10m in the west.

10. **The bus moving with a speed of 42 km/hr is brought to a stop by brakes after 6 m. If the same bus is moving at a speed of 90 km/hr, then the minimum stopping distance is**

(a) 15.48 m (b) 18.64 m

(c) 22.13 m (d) 27. 55 m

MHT-CET-2020
J&K-CET-2014

Ans. (d) : Given,

$u_1 = 0,\ s_1 = 6\text{m}$

$u_2 = 0,\ s_2 = ?$

$$u_1 = 42 \times \frac{5}{18} = 11.66\text{m/s}$$

$$u_2 = 90 \times \frac{5}{18} = 25 \text{ m/s}$$

For first case-

$$v_1^2 = u_1^2 + 2as_1$$

$$0 = (11.66)^2 + 2a \times 6$$

$$a = \frac{-11.66 \times 11.66}{12} = -11.33 \text{ m/s}^2$$

For second case-

$$v_2^2 = u_2^2 + 2as_2$$

$$0 = (25)^2 + 2(-11.33) \times s_2$$

$$s_2 = \frac{625}{2 \times 11.33} = 27.5 \text{ m}$$

11. **The ratio of displacement to distance for a moving particle is**

(a) Always less than one

(b) Always greater than one

(c) Always one

(d) One or less than one

AP EAMCET (17.09.2020) Shift-II
JIPMER-2011

Ans. (d) : Displacement is the shortest length between the start and end of a journey, while distance is the actual length of the path travelled.

Hence the distance will always be equal to or greater than the displacement.

∴ Distance ≥ Displacement

$$1 \geq \frac{\text{Displacement}}{\text{Distance}}$$

So, $\frac{\text{Displacement}}{\text{Distance}}$ is equal one or less than one

@apna_pdf

12. A particle starts moving from rest with uniform acceleration. It travels a distance x in first 2 seconds and distance y in the next 2 seconds. Then

(a) y = 2x (b) y = 3x
(c) y = 4x (d) y = x

AP EAMCET-22.09.2020, Shift-I
AP EAMCET(Medical)-2014

Ans. (b) : Given that,
Let x = distance covered in 2 sec

$$x = \frac{1}{2}.a.t^2 = \frac{1}{2}.a(2)^2 = 2a$$

And y = distance covered in next 2 sec

$$y = \frac{1}{2}.a(4)^2 - \frac{1}{2}.a.(2)^2$$

$y = 8a - 2a$

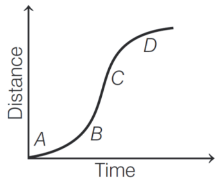
$\therefore\ y = 6a$

So, $\frac{x}{y} = \frac{2a}{6a} = \frac{1}{3}$

$3x = y$

$\therefore\ y = 3x$

13. A particle shows distance-time curve as given in this figure. The maximum instantaneous velocity of the particle is around the point



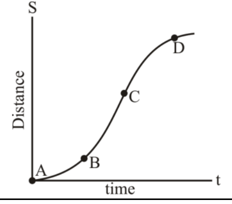
(a) B (b) C
(c) D (d) A

COMEDK-2020
[AIPMT 2008]

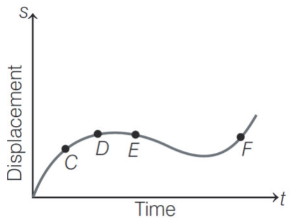
Ans. (b) :
Particle has maximum instantaneous velocity at the point at which the slope is maximum.

Therefore, $v_{max} = \frac{dx}{dt}$ = maximum slope

From figure it is obvious that an point C, slope is maximum hence at this point velocity is maximum.



14. The displacement-time graph of moving particle is shown below.



The instantaneous velocity of the particle is negative at the point

(a) D (b) F
(c) C (d) E

CG PET-2021
AIPMT-1994

Ans. (d): At point C, D and F the slope of curve $\left(\frac{ds}{dt}\right)$ is positive, so instantaneous velocity at these points are positive. At point E the slop of curve $\left(\frac{ds}{dt}\right)$ is negative. So instantaneous velocity of the particle at this point is negative.

15. The velocity of a particle is $v = v_0 + gt + Ft^2$. Its position is x= 0 at t = 0, then its displacement after time (t = 1) is

(a) $v_0 + g + F$ (b) $v_0 + \frac{g}{2} + \frac{F}{3}$
(c) $v_0 + \frac{g}{2} + F$ (d) $v_0 + 2g + 3F$

JEE Main-17.03.2021, Shift-II
AIEEE 2007

Ans. (b) : Velocity of particle (v) = $v_0 + gt + Ft^2$

$\because\quad v = \frac{dx}{dt}$

$\because\quad \frac{dx}{dt} = v_0 + gt + Ft^2$

$dx = (v_0 + gt + Ft^2)dt$

Now integrating the above equation

$$\int_0^x dx = \int_0^1 (v_0 + gt + Ft^2)dt$$

$$[x]_0^x = \left[v_0 t + \frac{gt^2}{2} + \frac{Ft^3}{3}\right]_0^1$$

$$\therefore\ x = v_0 + \frac{g}{2} + \frac{F}{3}$$

16. The displacement 'x' (in meter) of a particle of mass 'm' (in kg) moving in one dimension under the action of a force, is related to time 't' (in sec) by, $t = \sqrt{x} + 3$. The displacement of the particle when its velocity is zero, will be

(a) 6 m (b) 2 m
(c) 4 m (d) 0 m

Karnataka CET-2022
COMEDK 2013
CG PET-2010

Ans. (d) : Given that,

$t = \sqrt{x} + 3$

$\sqrt{x} = t - 3$

$x = t^2 + 9 - 6t$

We know that,

$v = \frac{dx}{dt}$

$v = 2t - 6$

@apna_pdf

As $v = 0$

$t = 3$ sec

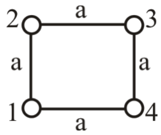
x at t = 3sec

$x = t^2 + 9 - 6t$

$x = (3)^2 + 9 - 6 \times 3$

$x = 0$

17. A track is in square shape. The length of each side is 'a'. There exists a pole at each corner as shown below. The person who walks on the track starts at the 1st pole and reach the 4th pole. The ratio of distance travelled by the person to displacement is



(a) $\frac{1}{3}$ (b) 3

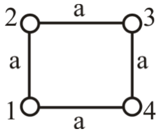
(c) $\frac{2}{3}$ (d) $\frac{3}{2}$

TS EAMCET 31.07.2022, Shift-II

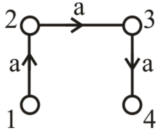
Ans. (b) : Given that,

length of each side = a

Given path is a square hence length of each side is equal that is 'a'



distance travelled by person from 1 to 4 from (1) to (2) then (2) to (3) and then (3) to (4).



distance (d) = a + a + a

d = 3a

displacement D = a

ratio of distance travelled to displacement = $\frac{d}{D}$

$= \frac{3a}{a}$

$= 3$

18. A biker travels $\frac{1}{3}$ of the distance L with speed v_1 and $\frac{2}{3}$ of the distance with speed v_2. Then the average speed is

(a) $\frac{V_1V_2}{V_1+V_2}$ (b) $\frac{3V_1V_2}{2V_1+V_2}$

(c) $\frac{3V_1V_2}{V_1+V_2}$ (d) $\frac{V_1+V_2}{V_1V_2}$

AP EAMCET-07.07.2022, Shift-I

Ans. (b) : Time taken to first $\frac{L}{3}$ distance,

$$t_1 = \frac{\frac{L}{3}}{v_1} = \frac{L}{3v_1}$$

Time taken to 2nd $\frac{2L}{3}$ distance,

$$t_2 = \frac{\frac{2L}{3}}{v_2} = \frac{2L}{3v_2}$$

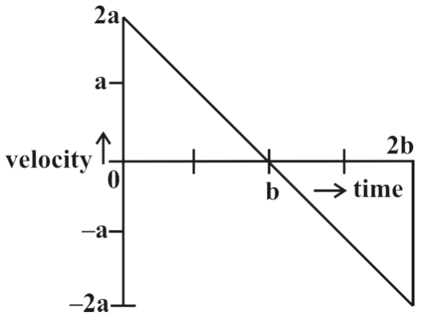
$$\text{Averaged speed } (v_{avg}) = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{L}{t_1 + t_2}$$

$$= \frac{L}{\frac{L}{3v_1} + \frac{2L}{3v_2}} = \frac{3v_1v_2L}{(v_2 + 2v_1)L}$$

$$= v_{avg} = \frac{3v_1v_2}{2v_1 + v_2}$$

19. When a small object of mass m is thrown vertically upward, the graphical representation of its velocity versus time is shown below:

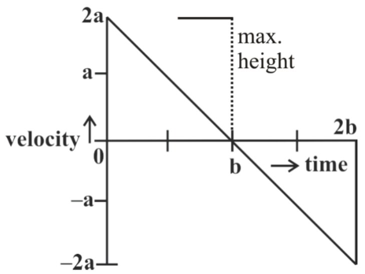


(a) 2a (b) 2b

(c) ab (d) 2ab

Tripura-27.04.2022

Ans. (c) :



Max. height = area under curve

$= \frac{1}{2} \times b \times 2a$

$= ab$

@apna_pdf

20. During a one dimensional motion, a particle of mass 'm' starts from rest at x = 0, t = 0 under the influence of a time dependent force F (t) = ma$_0$ cos (wt), where a$_0$ and w are two constants. The average velocity of the particle at t = $\frac{\pi}{w}$ is

(a) Zero (b) $\frac{a_0}{w}$

(c) $\frac{2a_0}{\pi w}$ (d) $\frac{-2a_0}{\pi w}$

Assam CEE-31.07.2022

Ans. (a) : Given,

F = ma$_0$ cos (wt)

ma = ma$_0$ cos (wt) $(\because F = ma)$

a = a$_0$ cos (wt)

$\frac{dv}{dt} = a_0 \cos(wt)$ $\left(\because a = \frac{dv}{dt}\right)$

dv = a$_0$ cos (wt)dt

Integrating on both sides, we get–

$$\int_0^{v_{avg}} dv = a_0 \int_0^{t=\pi/w} \cos(wt)dt$$

$$v_{avg} = \frac{a_0 \sin(wt)}{w}$$

$$v_{avg} = \frac{a_0 \sin\left(w \times \frac{\pi}{w}\right)}{w} \quad \left(\because t = \frac{\pi}{w}\right)$$

$$v_{avg} = \frac{a_0 \sin(\pi)}{w} = \frac{a_0}{w} \times 0 = 0$$

21. A car is moving with speed of 150 km/h and after applying the brake it will move 27 m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling _______ m distance.

JEE Main-25.07.2022, Shift-I

Ans. (3) :

speed of car = 150 km/h, d_1 = 27 m

We know–

$$F_R d = \frac{1}{2}mv^2$$

$$d \propto v^2$$

So,

$$\frac{d_2}{d_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{1}{3}\right)^2$$

$$d_2 = d_1 \times \frac{1}{9} = 27 \times \frac{1}{9} = 3m$$

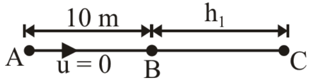
22. A small toy starts moving from the position of rest under a constant acceleration. If it travels a distance of 10 m in t s,. The distance travelled by the toy in the next t s will be:

(a) 10 m (b) 20 m

(c) 30 m (d) 40 m

JEE Main-29.06.2022, Shift-II

Ans. (c) : Let the toy start moving with acceleration 'a'



$\because$ Toy travels 10 m in t second and in next t second it travels h_1, distance as shown in figure.

$\because$ Toy starts from rest so, initial velocity = 0

Using Newton's 2nd law of motion-

$$s = ut + \frac{1}{2}at^2$$

From A to B it takes time t so,

$$10 = 0 + \frac{1}{2}at^2 \Rightarrow 10 = \frac{1}{2}at^2$$

From A to C it takes time (t + t = 2t) so,

$$(10 + h_1) = 0 + \frac{1}{2}a(2t)^2$$

$$(10 + h_1) = \frac{1}{2}a \times 4t^2 \Rightarrow (10 + h_1) = 4 \times \frac{1}{2}at^2$$

Now from equation (i)

$$(10 + h_1) = 4 \times 10 \Rightarrow (10 + h_1) = 40$$

$$h_1 = 40 - 10 = 30$$

$$h_1 = 30 \text{ m}$$

23. If $t = \sqrt{x} + 4$, then $\left(\frac{dx}{dt}\right)_{t=4}$ is :

(a) 4 (b) Zero

(c) 8 (d) 16

JEE Main-29.07.2022, Shift-I

Ans. (a) : $t = \sqrt{x} + 4$

$$\sqrt{x} = t - 4$$

Differentiating w.r.t. time (t)

$$\frac{d}{dx}\left(\sqrt{x}\right) = \frac{d}{dx}(t - 4)$$

$$\frac{1}{2\sqrt{x}}\frac{dx}{dt} = 1 - 0$$

$$\frac{dx}{dt} = 2\sqrt{x}$$

$$\left(\frac{dx}{dt}\right)_{x=4} = 2\sqrt{4}$$

$$\left(\frac{dx}{dt}\right)_{x=4} = 2 \times 2 = 4$$

$$\left(\frac{dx}{dt}\right)_{x=4} = 4$$

24. A balloon has mass of 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If the balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne).

(a) 3 (b) 9

(c) 12 (d) 18

JEE Main-28.07.2022, Shift-I

@apna_pdf

Ans. (b) : The average force acting on the balloon is given by-

$$F = m\frac{dv}{dt}$$

$\therefore$ $m = 10$ gm, $v = 4.5$ cm/s, $t = 5$s

$\therefore$ $F = 10\times\frac{4.5}{5}$

$F = 2 \times 4.5 = 9$ dyne

$F = 9$dyne

25. At time t = 0 a particle starts travelling from a height $7\hat{z}$ in a plane keeping z coordinate constant. At any instant of time it's position along the x and y directions are defined as 3t and $5t^3$ respectively. At t = 1s acceleration of the particle will be

(a) – 30y (b) 30y

(c) 3x + 15y (d) 3x + 15y + $7\hat{z}$

JEE Main-28.07.2022, Shift-II

Ans. (b) : The position vector of particle at time t is-

$$\vec{r} = 3t\hat{i} + 5t^3\hat{j} + 7\hat{z}$$

Velocity vector or particle

$$\frac{d\vec{r}}{dt} = 3\hat{i} + 5\times3t^2.\hat{j} + 0$$

Acceleration of particle-

$$\frac{d^2\vec{r}}{dt^2} = 0 + 15\times2t\hat{j}$$

$$\vec{a} = \frac{d^2\vec{r}}{dt^2} = 30t\hat{j}$$

$$\left(\frac{d^2\vec{r}}{dt^2}\right)_{t=1} = 30\times1\hat{j}$$

$$\frac{d^2\vec{r}}{dt^2} = 30\hat{j} = 30y$$

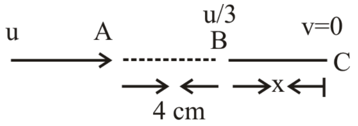
26. The velocity of the bullet becomes one third after it penetrates 4 cm in a wooden block. Assuming that bullet is facing a constant resistance during its motion in the block. The bullet stops completely after travelling at (4+x) cm inside the block. The value of x is:

(a) 2.0 (b) 1.0

(c) 0.5 (d) 1.5

JEE Main-27.07.2022, Shift-II

Ans. (c):



Let initial velocity of the bullet = u

After penetrating 4 cm its velocity becomes u/3.

From $v^2 = u^2 - 2as$

$$\left(\frac{u}{3}\right)^2 = u^2 - 2a(4)$$

$$\frac{u^2}{9} = u^2 - 8a$$

$$8a = u^2 - \frac{u^2}{9} = \frac{8u^2}{9}$$

$$a = \frac{u^2}{9}$$

Let further its will penetrate through distance x and stops at point C

For distance BC,

$$v = 0,\ u = \frac{u}{3}, s = x,\ a = \frac{u^2}{9}$$

From,

$$v^2 = u^2 – 2as$$

$$0 = \left(\frac{u}{3}\right)^2 - 2\times\frac{u^2}{9}\times x$$

$$0 = \frac{u^2}{9}(1-2x)$$

$1–2x = 0$

$1 = 2x$

$x = 0.5$

27. A particle is moving in a straight line such that its velocity is increasing at 5 ms^{-1} per meter. The acceleration of the particle is ____ ms^{-2}. at a point where its velocity is 20 ms^{-1}

JEE Main-25.07.2022, Shift-II

Ans. (100): We have

$$\frac{dv}{dt} = 5m/s$$

Acceleration of particle when v = 20 m/s

$$a = v\frac{dv}{dx}$$

$a = 20\times5$

$a = 100$ m/s^2

28. Assertion (A) : The zero velocity of a particle at any instant always implies zero acceleration at the instant

Reason (R) : A body is momentarily at rest when reverses its direction of motion.

The correct option among the following is

(a) (A) is true, (R) is the correct explanation for (A)

(b) (A) is true, (R) is true but (R) is not the correct explanation for (A)

(c) (A) is true but (R) is false

(d) (A) is false but (R) is true

TS EAMCET 18.07.2022, Shift-II

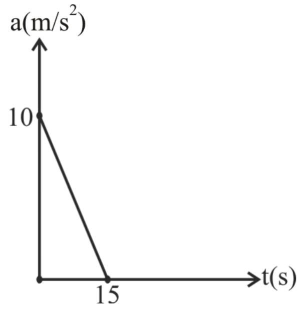
Ans. (d) : Acceleration is the time rate of charge of the velocity of a particle. A particle having zero velocity at any particle instant need not always implies zero acceleration at that instant.

When a particle is thrown vertically upward then at the highest point its velocity became zero but acceleration is not became zero. In other word, at the highest point of motion, a body is monitored in rest and start falling down (i.e. reverse its direction of motion) due to gravity of the earth.

Therefore, Assertion (A) is false and reason (R) is true.

@apna_pdf

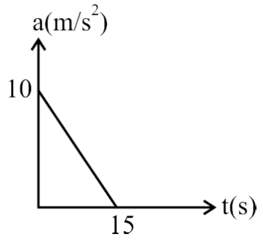
29. A particle starts from rest. Its acceleration (a) versus time (t) is as shown in the figure. The maximum speed of the particle will be



(a) 150 m/s (b) 75 m/s
(c) 37.5 m/s (d) 45 m/s

TS EAMCET 18.07.2022, Shift-II

Ans. (b) : Particle initial velocity (u) = 0 m/s



The velocity is maximum at 15 sec when the acceleration became zero.
As a–t graph gives the change in velocity

Hence, $v_{max} - 0 = \frac{1}{2} \times 10 \times 15$

$v_{max} = 75$ m/s

30. A motor car moving with velocity 7m/s stops in 10m distance when brakes are applied. What is the relation between the resistance force (R) and the weight of (W) the car ?
(Take value of $g = 9.8 m/s^2$)

(a) R = w (b) R = –w
(c) $R = -\frac{w}{2}$ (d) $R = -\frac{w}{4}$

TS EAMCET 19.07.2022, Shift-I

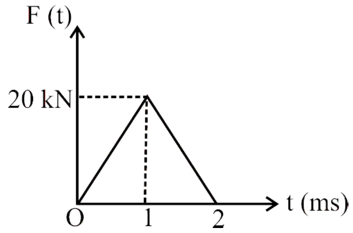
Ans. (d) : Given, u = 7 m/s
v = 0 m/s
s = 10 m

$v^2 = u^2 + 2as$
$0 = 7^2 + 2 \times a \times 10$
$-\frac{49}{20} = a$
$a = 2.45 \text{ m/s}^2$
$a = -\frac{g}{4}$

Now, force (f) = ma

$$f = m \times \left(-\frac{g}{4}\right) = -\frac{w}{4}$$

31. A time varying force acts on a ball of mass 100 g for 2 ms. The force versus time curve is shown below. If the initial speed of the ball is 10 m/s, then the speed of ball after 2 ms is



(a) 210 m/s (b) 410 m/s
(c) 200 m/s (d) 400 m/s

TS EAMCET 18.07.2022, Shift-I

Ans. (a) : Given, $m = 100g = 10^{-1}$ kg
u = 10m/s
$t = 2ms = 2 \times 10^{-3}s$
v = ?

Now, impulse,

$$I = \int_0^{2\times10^{-3}} F dt$$

$$= \frac{1}{2} \times 2 \times 10^{-3} \times 20 \times 10^3$$

= 20Ns ....(i)

Also, I = ΔP
20 = mv –mu {using equation (i)}
$20 = 10^{-1}(v - 10)$
v = 210m/s

32. A body starts from the rest and acquires a velocity of 10m/s in 2s. What is the acceleration of the body and the distance travelled

(a) 5 m/s^2 and 10 m (b) 5 m/s^2 and 5 m
(c) 5 m/s^2 and 6 m (d) 6 m/s^2 and 5 m

TS EAMCET 18.07.2022, Shift-I

Ans. (a) : Given, v = 10m/s, u = 0
t = 2s

$\therefore$ Acceleration (a) $= \frac{v-u}{t}$

$= \frac{10-0}{2}$

$a = 5 m/s^2$

and distance (s) $= ut + \frac{1}{2}at^2$

$= 0 \times 2 + \frac{1}{2} \times 5 \times (2)^2$

s = 10m

33. A rocket moves straight upward with zero initial velocity and with an acceleration 20 m/s². It runs out of fuel and stops accelerating at the end of 5th sec. It reaches a maximum height and falls back to the earth. The speed when it hits the ground is (Take g = 10m/s²)

@apna_pdf

(a) $100\sqrt{2}\text{m/s}$ (b) $150\sqrt{3}\text{m/s}$
(c) $50\sqrt{6}\text{m/s}$ (d) 75m/s

TS EAMCET 19.07.2022, Shift-II

Ans. (c) : Given, $u = 0$, $a = 20\ \text{m/s}^2$, $t = 5\text{sec.}$

$$v = u + at$$
$$v = 0 + 20 \times 5$$
$$v = 100\ \text{m/s.}$$
$$s = ut + \frac{1}{2}at^2 = 0 \times 5 + \frac{1}{2} \times 20 \times (5)^2 = 250\text{m}$$

Distance covered by rocket = 250m

Speed, when it hits the ground

$$(v')^2 = v^2 + 2gs$$
$$(v')^2 = (100)^2 + 2 \times 10 \times 250 = 15000$$
$$v' = 50\sqrt{6}\text{m/s}$$

34. Two towns X and Y are connected by a regular bus service. A bus leaves in either direction at every t = T minutes. A man moving with some speed in the direction X to Y finds that a bus goes past him every t = t_1 minutes in the direction of his motion, and every t = t_2 minutes in the opposite direction. Then T is given by

(a) $\frac{2t_1t_2}{t_1+t_2}$ (b) $\frac{(t_1-t_2)t_1}{t_1+t_2}$
(c) $\frac{2t_2(t_1+t_2)}{|t_1-t_2|}$ (d) $\frac{t_1t_2}{|t_1-t_2|}$

TS EAMCET 20.07.2022, Shift-I

Ans. (a) : As both bus and man are moving in the same direction their relative velocity will be –

Relative velocity of bus, $v_B = v_B - v_M$

Distance covered $= v_BT$

$$(v_B - v_M) \times t_1 = v_BT \quad \text{....(i)}$$

When bus is moving from B to A,

Distance covered $= v_BT$

$$(v_B + v_M) \times t_2 = v_BT \quad \text{.....(ii)}$$

Equating equation (i) and (ii), we get–

$$(v_B - v_M)t_1 = (v_B + v_M)t_2$$
$$v_B = v_M\left(\frac{t_1+t_2}{t_1-t_2}\right) \quad \text{....(iii)}$$

Now, from equation (i) and (iii), we get–

$$\left[v_m\left(\frac{t_1+t_2}{t_1-t_2}\right) - v_m\right]t_1 = v_m\left(\frac{t_1+t_2}{t_1-t_2}\right)T$$
$$\left(\frac{t_1+t_2}{t_1-t_2}\right)t_1 - t_1 = \left(\frac{t_1+t_2}{t_1-t_2}\right)T$$
$$t_1 - \left(\frac{t_1-t_2}{t_1+t_2}\right)t_1 = T$$
$$\frac{t_1^2+t_1t_2-t_1^2+t_1t_2}{t_1+t_2} = T$$
$$\frac{2t_1t_2}{t_1+t_2} = T$$

35. The co-ordinates (x, y) of a moving particle at any time 't' are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time 't' is given by

(a) $3t\sqrt{a^2+\beta^2}$ (b) $3t^2\sqrt{\alpha^2+\beta^2}$
(c) $t^2\sqrt{\alpha^2+\beta^2}$ (d) $\sqrt{\alpha^2+\beta^2}$

TS EAMCET 31.07.2022, Shift-II

Ans. (b) : Given, $x = \alpha t^3$ and $y = \beta t^3$

Now, speed, $v_x = \frac{dx}{dt} = 3\alpha t^2$ and $v_y = \frac{dy}{dt} = 3\beta t^2$

Hence, the speed of particle,

$$v = \sqrt{v_x^2 + v_y^2}$$
$$= \sqrt{(3\alpha t^2)^2 + (3\beta t^2)^2}$$
$$v = 3t^2\sqrt{\alpha^2+\beta^2}$$

36. Acceleration a is given in terms of position x as a = 2x m/s^2. At x = 0, the velocity v is zero. What is the relation between velocity v and position x?

(a) $v = \sqrt{2}x$ (b) $v = 2x$
(c) $v^2 = 2x$ (d) $v = \frac{x^2}{2}$

TS EAMCET 31.07.2022, Shift-II

Ans. (a) : Acceleration is given in terms of position x as

$$a = 2x\ \text{m/s}^2$$
$$\because \quad a = \frac{dv}{dx}.v = 2x$$
$$vdv = 2x\,dx$$

By Integrating both side,

$$\int vdv = \int 2xdx$$
$$\frac{v^2}{2} = 2 \cdot \frac{x^2}{2}$$
$$\frac{v^2}{2} = x^2$$
$$v^2 = 2x^2$$
$$v = \sqrt{2}x$$

37. Particle A (which was located at the origin at time t = 0) is moving along the x - axis with a constant speed of 1 m/s. Location of particle B which is moving along the Y - axis is given by y = ct^2, where c = 1 m/s^2. Find the speed of particle A relative to particle B at t = 1 sec.

(a) $\sqrt{5}\text{m/s}$ (b) 2 m/s
(c) 1 m/s (d) 0 m/s

TS EAMCET 20.07.2022, Shift-II

Ans. (a) : Speed of particle A, $v_A = 1\text{m/s}$

Given: $y = ct^2$

$$v_B = \frac{dy}{dt} = c.2t = 2t \qquad \{\because c = 1\ \text{m/s}^2)$$

at t = 1 sec

@apna_pdf

$v_B = 2$ m/s

Now, the speed of particle A relative to particle B at t = 1sec is

$$v_{AB} = \sqrt{v_A^2 + v_B^2}$$

$$v_{AB} = \sqrt{(1)^2 + (2)^2}$$

$$v_{AB} = \sqrt{5} \text{ m/s}$$

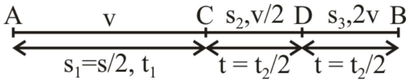
38. A car travelled half the distance with a velocity 'v' and it covered the remaining half distance with a velocity $\left(\frac{v}{2}\right)$ in the first half time and with velocity '2v' in the second half time. The average velocity of the car for the whole journey is

(a) $\frac{10v}{14}$ (b) $\frac{10v}{9}$

(c) $\frac{7v}{4}$ (d) $\frac{10v}{7}$

TS EAMCET 30.07.2022, Shift-I

Ans. (b) :



Distance = Velocity × time

Distance cover C to B,

$$s_1 = \frac{v}{2} \times \frac{t_2}{2} = \frac{vt_2}{4}$$

$$s_2 = 2v \times \frac{t_2}{2} = vt_2$$

$$\because \quad \frac{s}{2} = s_1 + s_2 = \frac{vt_2}{4} + vt_2 = \frac{5vt_2}{4}$$

$$t_2 = \frac{4s}{2 \times 5v} = \frac{2s}{5v}$$

Distance cover A to C,

$$\frac{s}{2} = v \times t_1 \Rightarrow t_1 = \frac{5}{2v}$$

Total time (T) = $t_2 + t_1$

$$= \frac{2s}{5v} + \frac{s}{2v} = \frac{4s + 5s}{10v} = \frac{9s}{10v}$$

$$\because \text{ Average velocity } (v_{avg}) = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{s}{9s/10v}$$

$$\boxed{v_{avg} = \frac{10v}{9}}$$

39. The relationship between the final velocity v and the distance x travelled by a bus moving with uniform acceleration is $v = \sqrt{256\text{-}10x}$. The acceleration of the bus is (All quantities are given in SI units)

(a) -5 m/s^2 (b) -10 m/s^2

(c) -20 m/s^2 (d) -15 m/s^2

TS EAMCET 31.07.2022, Shift-II

Ans. (a) :

Velocity of the particle is given by

$$v = \sqrt{256 - 10x}$$

Squaring both side, we get

$$v^2 = 256 - 10x$$

Differentiating both side w.r.t. t

$$2v\frac{dv}{dt} = 0 - 10\frac{dx}{dt}$$

We know that, differentiation of velocity w.r.t. time gives acceleration. Also differentiation of displacement gives velocity $\frac{dx}{dt} = v$

$$2va = 0 - 10v$$

$$2a = -10$$

$$a = -5 \text{ m/s}^2$$

40. A particle moves in a straight line with uniform acceleration and with initial velocity of 2m/s. Its average velocity after moving for 4s is 6 m/s. The acceleration of the particle.

(a) 3 m/s^2 (b) 2 m/s^2

(c) 4 m/s^2 (d) 1 m/s^2

TS EAMCET 31.07.2022, Shift-II

Ans. (b) :

$$\text{Average velocity } (v_{avg.}) = \frac{\text{displacement(s)}}{\text{time(t)}}$$

Given, $v_{avg} = 6$ m/s, t = 4 sec, u = 2 m/sec

$$s = v.t = 6 \times 4$$

Displacement (s) = 24 m

$$\text{Using,} \quad s = ut + \frac{1}{2}at^2$$

$$24 = 2 \times 4 + \frac{1}{2}a \times (4)^2$$

$$24 = 8 + 8a$$

$$8a = 16$$

$$a = 2 \text{ m/s}^2$$

41. A particle is moving along x-axis with velocity $v = e^{-\beta x}$. At time t = 0, the particle is located at x = 0. The displacement of the particle as function of time is

(a) $e^{-\beta t}$ (b) $\frac{1}{\beta}e^{(1-\beta t)}$

(c) $\frac{1}{\beta}\log[1-\beta t]$ (d) $\frac{1}{\beta}\log[1+\beta t]$

AP EAMCET-07.07.2022, Shift-I

Ans. (d) : $V = e^{-\beta x}$, At time (t) = 0 & x = 0

$$V = \frac{dx}{dt} \Rightarrow \frac{dx}{dt} = e^{-\beta x}$$

$$e^{\beta x}.dx = dt$$

Integrating both sides,

$$\int_o^x e^{\beta x}.dx = \int_o^t dt$$

@apna_pdf

$$\left[\frac{e^{\beta x}}{\beta}\right]_o^x = [t]_o^t$$

$$\frac{e^{\beta x}}{\beta}-\frac{1}{\beta}=t \Rightarrow \frac{e^{\beta x}}{\beta}=\frac{1}{\beta}+t$$

$$e^{\beta x} = 1+\beta t$$

$$\beta x = \log(1+\beta t)$$

$$x=\frac{1}{\beta}\log(1+\beta t)$$

42. The velocity of a particle is only a function of its position $v(x) = e^{-x}$. The position of the particle at time t = 0 is x = 0. The displacement of the particle varies with time as

(a) e^t (b) $e^{(1-t)}$

(c) ln (t) (d) ln(1+t)

AP EAMCET-12.07.2022, Shift-I

Ans. (d) : Given,

velocity of a particle $v(x) = e^{-x}$ ....(i)

$$\because \quad v=\frac{dx}{dt}$$

$$\frac{dx}{dt}=e^{-x} \qquad \text{(From equation (i))}$$

$$\frac{dx}{e^{-x}}=dt$$

$$e^{x}dx=dt$$

Integrating the above equation from t = 0 to t

$$\therefore \int_0^x e^x dx=\int_0^t dt$$

$$\left[e^x\right]_0^x=[t]_0^t$$

$$e^x-e^0=t-0$$

$$e^x-1=t$$

$$e^x=t+1$$

Taking the log both side,

$$\log_e(e^x) = \log_e(t+1)$$

$$x\log_e(e) = \log_e(t+1)$$

$$x = \ln(1+t) \qquad (\log_e e = 1)$$

43. $y = (Pt^2 - Qt^3)$ m is the vertical displacement of a ball which is moving in vertical plane. Then the maximum height that the ball can reach is

(a) $\frac{27P^3}{4Q^2}$ (b) $\frac{4Q^2}{27P^3}$

(c) $\frac{4P^3}{27Q^2}$ (d) $\frac{27Q^2}{4P^3}$

AP EAMCET-04.07.2022, Shift-II

Ans. (c) : In vertical plane the vertical displacement of ball is given as –

$$y = (Pt^2 - Qt^3) \qquad ...(i)$$

For maximum height,

$$\frac{dy}{dt}=0$$

$$\frac{d}{dt}\left(Pt^2-Qt^3\right)=0$$

$$\left(2Pt-3Qt^2\right)=0$$

$$t\left(2P-3Qt\right)=0$$

$$2P-3Qt=0$$

$$t=\frac{2P}{3Q}$$

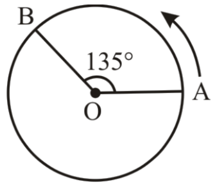
Putting the value of t in equation (i),

$$y_{max}=\frac{4P^3}{9Q^2}-\frac{8P^3}{27Q^2}$$

$$y_{max}=\frac{4P^3}{27Q^2}[3-2]$$

$$y_{max}=\frac{4P^3}{27Q^2}$$

44. A person moved from A to B on a circular path as shown in figure. If the distance travelled by him is 60 m, then the magnitude of displacement would be: (Given cos 135° = –0.7)



(a) 42 m (b) 47 m

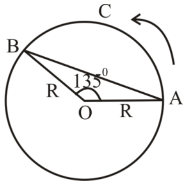
(c) 19 m (d) 40 m

JEE Main-25.07.2022, Shift-I

Ans. (b) : Distance travelled by

Person = 60 m (Arc ACB)

Let, R = Radius



Displacement is shortest distance between two point.

So, Displacement of person = AB (Straight line)

Using consines rule in triangle BOA.

$(AB)^2 = (OA)^2 + (OB)^2 – 2(OA)(OB)\cos(BOA)$

$(AB)^2 = R^2 + R^2 – 2R \times R\cos 135^o$

$(AB)^2 = 2R^2 – 2R^2 \times (–0.7) \qquad (\because \cos 135^o = –0.7)$

AB = 1.84 R .... (i)

Circumference of circle = 2πR

$$R=60\times\frac{360}{135\times 2\pi}=\frac{80}{\pi}$$

$$=\frac{80}{22}\times 7$$

R = 25.45 m

Putting value of R in eq^n (i) we have.

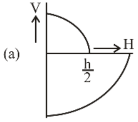
AB = 1.84 R = 1.84×25.45

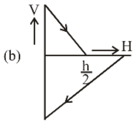
AB = 46.92 m

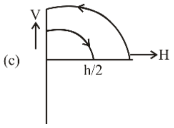
AB ≅ 47m

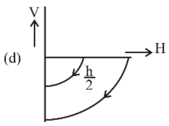
@apna_pdf

45. **An object is released from a height of h and after rebound it attains a height of $\frac{h}{2}$. Which of the following velocity (V) vs. height (H) graphs describes this journey correctly? (velocity in upward direction is positive)**

(a)


(b)


(c)


(d)


Tripura-2021

Ans. (a) : $V^2 = u^2 + 2gh$ downward velocity is negative and upward is positive when ball is coming down graph will be in IV quadrant i.e. v is –ve and when going up graph will be in I quadrant i.e. v is +ve.

46. **The relation between time t and distance x for a moving body is given as $t = mx^2 + nx$, where m and n are constants. The retardation of the motion is (when v stands for velocity)**

(a) $2\ mv^3$ (b) $2\ mnv^3$
(c) $2\ nv^3$ (d) $2n^2v^3$

JEE Main-25.07.2021, Shift-II

Ans. (a) : Given,

$t = mx^2 + nx$

Differentiating the above equation with respect to time, we have

$$\frac{dt}{dt} = m\frac{d(x^2)}{dt} + n\frac{dx}{dt}$$

$$1 = 2mx\frac{dx}{dt} + n\frac{dx}{dt} = 2mxv + nv$$

$$1 = v(2mx + n)$$

$$v = \frac{1}{2mx + n}$$

$$a = \frac{dv}{dt} = \frac{-2m(dx/dt)}{(2mx+n)^2} = -2m \times v^2 \times v = -2\ mv^3$$

$\therefore$ The retardation of the motion is $2mv^3$.

47. **If the velocity of a body related to displacement x is given by $v = \sqrt{5000 + 24x}$ m/s then the acceleration of the body is.... m/s^2.**

JEE Main-27.08.2021, Shift-I

Ans. (12) : Given,

$$v = \sqrt{5000 + 24x}\ m/s$$

$$v^2 = 5000 + 24x \qquad \ldots\ldots\ldots..(1)$$

On differentiating equation (1) w.r.to x, we get–

$$2v\frac{dv}{dx} = \frac{d}{dx}(5000 + 24x)$$

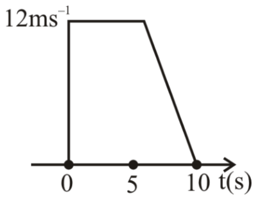
$$2v\frac{dv}{dx} = 0 + 24$$

$$v\frac{dv}{dx} = 12$$

$$a = \frac{dx}{dt}.\frac{dv}{dx} = 12$$

Hence, acceleration of the body is 12 m/s^2.

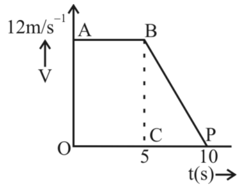
48. **The speed-time graph of a particle along a fixed direction is shown below. The distance traversed by the particle between t=0s and t=10s will be**



(a) 120 m (b) 90 m
(c) 60m (d) 30 m

Assam CEE-2021

Ans. (b) :



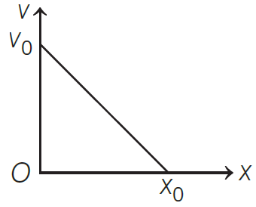
Distance travelled by the particle = Area under the v-t graph

Area of × ABCO + area of ΔBCP

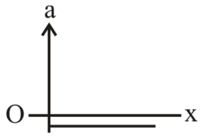
$$= 5 \times 12 + \frac{1}{2} \times 12 \times 5$$

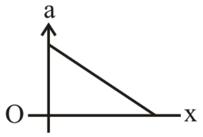
= 60 + 30 = 90 m

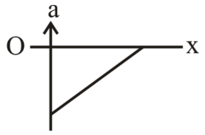
49. **The velocity- displacement graph of a particle is shown in the figure.**

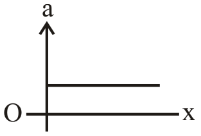


The acceleration-displacement graph of the same particle is represented by

(a)


(b)


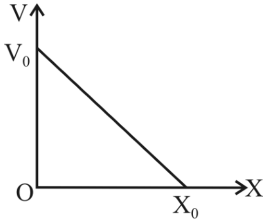
(c)


(d)


JEE Main-18.03.2021, Shift-II

@apna_pdf

Ans. (c) : Given,
initial velocity = v_0
Let, the distance travelled in time t = x_0



For the graph $\tan\theta = \frac{-v_0}{x_0}$ ..... (i)

Therefore

$$v = \left(-\frac{v_0}{x_0}\right)x + v_0$$

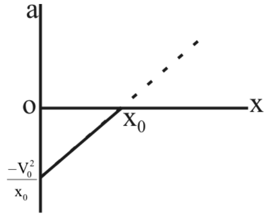
And, $a = \frac{vdv}{dx}$

$$a = \left[\left(-\frac{v_0}{x_0}\right)x + v_0\right].\frac{d}{dx}\left[\left(-\frac{v_0}{x_0}\right)x + v_0\right]$$

$$a = \left[\left(-\frac{v_0}{x_0}\right)x + v_0\right]\left[\left(-\frac{v_0}{x_0}\right) + 0\right]$$

$$a = \frac{v_0^2}{x_0^2}x - \frac{v_0^2}{x_0}$$

Again comparing with standard equation of straight line
$y = mx + c$
here, m = +ve, c = –ve



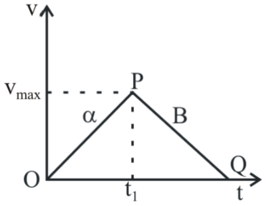
50. A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t seconds, the total distance travelled is

(a) $\frac{4\alpha\beta}{(\alpha+\beta)}t^2$ (b) $\frac{2\alpha\beta}{(\alpha+\beta)}t^2$

(c) $\frac{\alpha\beta}{2(\alpha+\beta)}t^2$ (d) $\frac{\alpha\beta}{4(\alpha+\beta)}t^2$

AIPMT 1994
JEE Main-17.03.2021, Shift-I

Ans. (c) :



The slope of line OP,

$$\alpha = \frac{v_{max}}{t_1} \Rightarrow v_{max} = \alpha t_1 \qquad ....(i)$$

Slope of line PQ

$$\beta = \frac{v_{max}}{t - t_1} \Rightarrow v_{max} = \beta(t - t_1) \qquad .....(ii)$$

From equation (i) and (ii) we get

$$\alpha t_1 = \beta\ (t - t_1)$$
$$\alpha t_1 = \beta t - \beta t_1$$
$$\alpha t_1 + \beta t_1 = \beta t$$
$$t_1(\alpha + \beta) = \beta t$$
$$t_1 = \frac{\beta t}{\alpha + \beta} \qquad ....(iii)$$

∵ Total distance travelled

$$s = \text{Area of } v - t \text{ graph}$$
$$= \frac{1}{2} \times v_{max} \times t$$
$$s = \frac{1}{2}v_{max}t \ .... \ (iv)$$

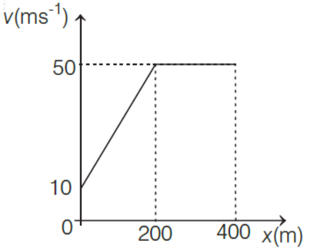
Substituting value of t_1 in equation (i) we get

$$v_{max} = \frac{\alpha\beta t}{\alpha + \beta}$$

Substituting value of v_{max} in equation (iv) we get

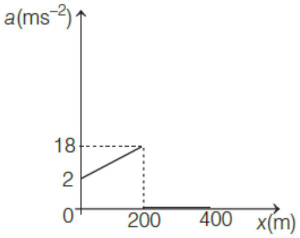
$$s = \frac{\alpha\beta}{2(\alpha + \beta)}t^2$$

51. The velocity-displacement graph describing the motion of a bicycle is shown in the following figure.

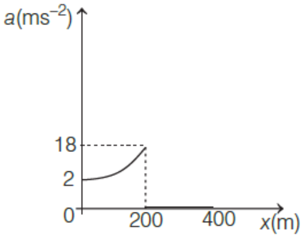


The acceleration-displacement graph of the bicycle's motion is best described by.

(a)

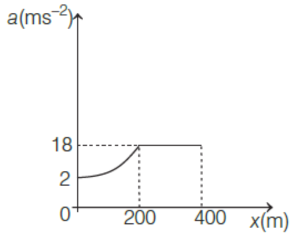


(b)

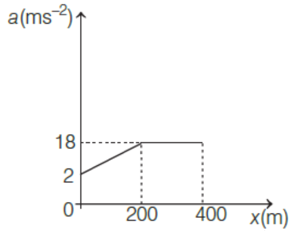


@apna_pdf

(c)

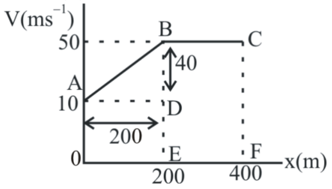


(d)



JEE Main-16.03.2021, Shift-I

Ans. (a) :



From x = 0 to 200m,

$\because$ $y = mx + c$

$v = mx + c$

$$= \frac{40}{200}x + c$$

$$v = \frac{1}{5}x + c \quad \ldots\ldots(i)$$

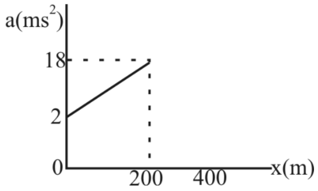
$$a = \frac{vdv}{dx}$$

$$a = \left(\frac{x}{5} + 10\right)\left(\frac{1}{5}\right)$$

$$a = \frac{x}{25} + 2$$

Straight line till x = 200

$\because$ For x > 200, v = constant, a = 0



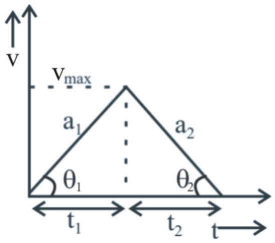
52. **A scooter accelerates from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be**

(a) $\frac{a_1 + a_2}{a_2}$ (b) $\frac{a_2}{a_1}$

(c) $\frac{a_1}{a_2}$ (d) $\frac{a_1 + a_2}{a_1}$

JEE Main-26.02.2021, Shift-II

Ans. (b) :



From (v–t) graph

$$\tan\theta_1 = \frac{v_{max}}{t_1} = a_1 \quad \ldots\ldots..(i)$$

$$\tan\theta_2 = \frac{v_{max}}{t_2} = a_2 \quad \ldots\ldots(ii)$$

From equation (i) and (ii) we get

$$\frac{a_1}{a_2} = \frac{v_{max}/t_1}{v_{max}/t_2} = \frac{t_2}{t_1}$$

$$\because \quad \frac{a_2}{a_1} = \frac{t_1}{t_2}$$

53. **A cyclist traversed half the distance of a linear track with a velocity 10 m/s. The remaining part of the track was covered with a velocity $\vec{v}_1$ for half the time and a velocity $\vec{v}_2$ for the other half of the time. If $\vec{v}_1 + \vec{v}_2 = 20 m/s$, then the average velocity of the cyclist during the completion of the journey through the track is:**

(a) 30 m/s (b) 20 m/s

(c) 10 m/s (d) 15 m/s

TS EAMCET 05.08.2021, Shift-II

Ans. (c) : Total distance travelled = s

To travel half distance, time taken first half = t_1

Second half = t_2

Distance travelled in first half = s/2, v_0 = 10

$$t_1 = \frac{5/2}{v_0} = \frac{5}{2v_0} = \frac{5}{2\times 10} = \frac{5}{20}$$

Time taken to cover second half is t_2

$$\therefore \frac{5}{2} = \frac{t_2\vec{v}_1}{2} + \frac{t_2\vec{v}_2}{2}$$

$5 = t_2(v_1 + v_2)$

$5 = t_2 \times 20$

$$t_2 = \frac{5}{20}$$

Total time taken = $t_1 + t_2$

$$= \frac{5}{20} + \frac{5}{20} = \frac{10}{20} = \frac{5}{10}$$

$$\text{Average velocity} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{5}{5/10}$$

= 10 m/sec

@apna_pdf

54. A car travels in a straight line along a road. Its distance 'x' from a stop sign is given as a function of 't' by the equation $x(t) = \alpha t + \beta t^3$, where $\alpha = 2.0$ m/s, $\beta = 0.01$ m/s^3 . Calculate the average velocity of the car in the time interval t = 2.00 sec to 4.00 sec.

(a) 2.28 m/s (b) 4.94 m/s
(c) 3.34 m/s (d) 4.12 m/s

TS EAMCET 04.08.2021, Shift-I

Ans. (a) : Distance x function of 't'

$x(t) = \alpha t + \beta t^3$

time interval

$t_1 = 2$ sec, $t_2 = 4$ sec.

So,

$x_1 = 2\times2 + 0.01\times2^3$
$= 4+0.08$
$= 4.08$

$x_2 = 2\times4 + 0.01\times 4^3$
$=8+0.64$
$= 8.64$

The average velocity, $v_{avg.} = \dfrac{\Delta x}{\Delta t} = \dfrac{x_2 - x_1}{t_2 - t_1}$

$$v_{avg.} = \frac{8.64-4.08}{4-2}$$

$$v_{avg} = \frac{4.56}{2}$$

$$v_{avg.} = 2.28 \text{ m/sec}$$

55. The velocity of a particle moving along the x - axis varies as a function of time t as $v(t) = (1-3t^2+2t^3)$ ms.If its position at t = 0 is x = 0 then at t = 2s, its position is

(a) 1 m (b) 2 m
(c) 4 m (d) 18 m

TS EAMCET 04.08.2021, Shift-II

Ans. (b) : $v(t) = 1 - 3t^2 + 2t^3$

$\because \quad v = \dfrac{dx}{dt}$

Integrating w.r.t. t we get,

$$\frac{dx}{dt} = (1-3t^2+2t^3)$$

$$\int dx = \int (1-3t^2+2t^3)dt$$

$$x = t - \frac{3t^3}{3} + \frac{2t^4}{4} + C$$

$$x = t - t^3 + \frac{t^4}{2} + C$$

When, $t = 0$ $x = 0 \rightarrow C = 0$

At t = 2

$$x = 2 - 2^3 + \frac{2^4}{2} + 0$$

$x = 2 - 8 + 2^3 + 0$

$x = -6 + 8$

$x = 2$ m

56. At time t = 0, a particle leaves the origin and moves in the positive direction of the X-axis. If the velocity of the particles varies as $\overline{V}(t) = \overline{V}_0\left(1-\dfrac{t}{t_0}\right), \left|\overline{V}_0\right| = 10$m/s and $t_0 = 10$ s, then the distance covered by the particle during the first 20 s is:

(a) 200 m (b) 100 m
(c) 0 m (d) 400 m

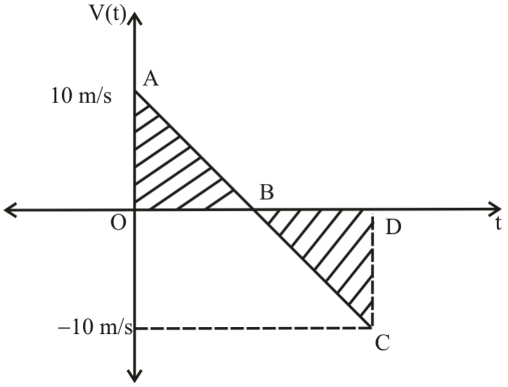
TS EAMCET 06.08.2021, Shift-I

Ans. (b) :

$$\overline{V}(t) = \overline{V}_0\left(1-\frac{t}{t_0}\right)$$

$$V(t) = 10\left[1-\frac{t}{10}\right]$$

$$V(t) = 10 - t$$

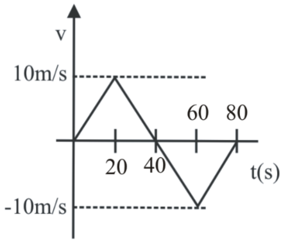


Total Distance = Area of △OAB + Area of △BCD.

$$= \frac{1}{2}\times10\times10 + \frac{1}{2}\times10\times10$$

$= 50 + 50 = 100$ m

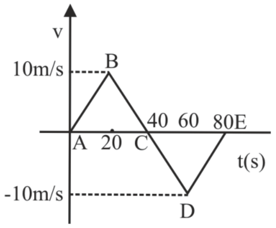
57. For the following velocity-time graph, the average speed for the motion during first 80 seconds



(a) 0 (b) 5 m/s
(c) 10 m/s (d) 0.25 m/s

TS EAMCET 06.08.2021, Shift-I

Ans. (b) :



@apna_pdf

$$\because \text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

Total Distance = Area of Δ ABC + Area of Δ CDE

$$= \frac{1}{2}\times 40\times 10+\frac{1}{2}\times(80-40)\times 10$$

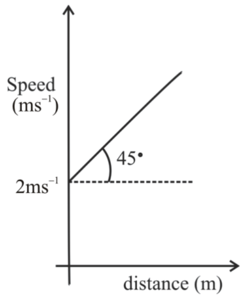
$$= 200 + 200$$

$$\text{Average Speed} = \frac{200+200}{80}$$

$$= \frac{400}{80}$$

Average Speed = 5 m/s

58. The speed distance graph is shown below. At what instant of time (in sec) the speed becomes 4 m/s?



(a) t = ln(2) (b) t = ln(4)
(c) t = ln(8) (d) t = ln(6)

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (a) : From Graph

$v = s + 2$

At v = 4 m/s, s = 2 m

We know that, $v = \frac{ds}{dt}$

$v = s + 2$

$$\frac{ds}{dt} = s + 2$$

$$\int \frac{ds}{s+2} = \int dt$$

$\ln (s+2) = t + k$ ....(1)

Given, s = 0, t = 0

$k = \ln(2)$

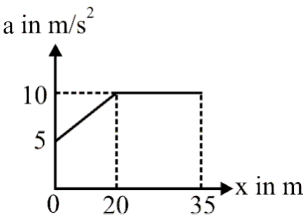
From eqn (1),

$\ln (4) = t + \ln (2)$

$\ln (4) - \ln (2) = t$

$t = \ln(2)$

59.



The acceleration vs distance graph for a particle moving with initial velocity 5 m/s is shown in the figure. The velocity of the particle at x = 35 m will be

(a) 20.62 m/s (b) 20 m/s
(c) 25 m/s (d) 50 m/s

WB JEE 2021

Ans. (c) : We know,

$$\text{Area under the graph} = \int a.ds$$

and $$\text{Acceleration} = \frac{\text{Velocity}}{\text{time}}$$

$$a = V.\frac{dv}{ds}$$

Integrating both sides,

$$\int_{S_1}^{S_2} a.ds = \int_{v_1}^{v_2} v.dv$$

$$\text{Area under graph} = \int_{v_1}^{v_2} v.dv$$

$$\left[\frac{1}{2}(5+10)\times 20\right]+[15\times 10]=\int_{v_1}^{v_2} v.dv$$

$$[150+150]=\left[\frac{v^2}{2}\right]_{v_1}^{v_2}$$

$$300 = \frac{v_2^2-v_1^2}{2}$$

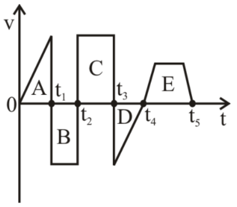
$$300 = \frac{v_2^2-(5)^2}{2}$$

$600 = v_2^2 - 25$

$v_2 = \sqrt{625}$

$\therefore\ v_2 = 25 m/s$

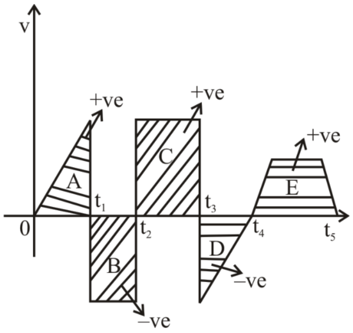
60. The velocity-time graph of an object is as shown. The displacement during the interval 0 to t_4 is



(a) area (A) + area (B) + area (C) + area (D) + area (E)
(b) area (A) – area (B) + area (C) – area (D)
(c) area (A) + area (B) + area (C) + area (D)
(d) area (A) – area (B) + area (C) + area (D) + area (E)

AP EAMCET-06.09.2021, Shift-I

Ans. (b) :



@apna_pdf

Displacement = Area under the v-t graph.
Displacement become positive above the origin line and negative below the line
During the interval 0 to t_4,
Displacement (0 to t_4) = Area (A) – Area (B) + Area (C) – Area (D)

61. A boat of length L and mass M is floating on a stationary lake water. A person of mass m walks on the boat from one end to the other. Displacement incurred by the boat with respect to bank of the lake is

(a) $\frac{M}{M-m}L$ (b) $\frac{m}{M-m}L$

(c) $\frac{M}{M+m}L$ (d) $\frac{m}{M+m}L$

Tripura-2021

Ans. (d) : Given as,
Boat length = L
Mass of man = m
Mass of boat = M
Let x = displacement of boat in water

$$x_1(\text{initial}) = \frac{mL + M\frac{L}{2}}{m+M}$$

$$x_2(\text{final}) = \frac{mx + M\left(\frac{L}{2}+x\right)}{m+M}$$

Now, $x_1 = x_2$

$$mL + \frac{ML}{2} = mx + \frac{ML}{2} + Mx$$

$$x = \frac{mL}{m+M}$$

62. The instantaneous velocity of a particle moving in a straight line is given as $v = \alpha t + \beta t^2$, where α and β are constants. The distance travelled by the particle between 1s and 2s is

(a) $3\alpha + 7\beta$ (b) $\frac{3}{2}\alpha + \frac{7}{3}\beta$

(c) $\frac{\alpha}{2} + \frac{\beta}{3}$ (d) $\frac{3}{2}\alpha + \frac{7}{2}\beta$

JEE Main-25.07.2021, Shift-II

Ans. (b) : The instantaneous velocity of a particle is given as –

$$v = \alpha t + \beta t^2$$

$$\because \quad v = \frac{dx}{dt}$$

$$\therefore \quad \frac{dx}{dt} = \alpha t + \beta t^2$$

$$dx = \left(\alpha t + \beta t^2\right)dt$$

Integrating the above equation from, t = 1 to 2

$$\int_1^2 dx = \int_1^2 [\alpha t]dt + \int_1^2 \beta t^2 dt$$

$$[x]_1^2 = \frac{[\alpha t]_1^2}{2} + \frac{[\beta t^3]_1^2}{3}$$

$$[x]_1^2 = \frac{\alpha}{2}\left[2^2 - 1^1\right] + \frac{\beta}{3}\left[2^3 - 1^3\right]$$

$$[x]_1^2 = \frac{\alpha}{2}[4-1] + \frac{\beta}{3}[8-1]$$

$$\Delta x = (x_2 - x_1) = \frac{3\alpha}{2} + \frac{7\beta}{3}$$

63. A time dependent force is acting on a body of which the velocity of body can be expressed as $\alpha t^{3/2}$. The displacement of the body between time t = 2 and 5 sec is about.

(a) $20\,\alpha$ (b) $22\,\alpha$

(c) $6\,\alpha$ (d) 0

Assam CEE-2021

Ans. (a) : Velocity of the body is given as –

$$v = \alpha t^{3/2}$$

To find out the displacement between time (t) = 2 second to 5 second

$$v = \frac{dx}{dt}$$

$$\therefore \quad \frac{dx}{dt} = \alpha t^{3/2}$$

$$dx = \alpha t^{3/2} dt$$

Integrating the above equation from t = 2 to 5s–

$$\int_2^5 dx = \int_2^5 \alpha t^{3/2} dt$$

$$[x_5 - x_2] = \alpha\left[\frac{t^{5/2}}{5/2}\right]_2^5$$

$$\Delta x = \alpha \times \frac{2}{5}\left[5^{2.5} - 2^{2.5}\right]$$

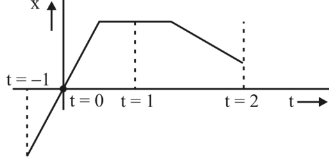
$$\Delta x = \alpha \times \frac{2}{5}[55.90 - 5.65]$$

$$\Delta x = \frac{2\alpha}{5}[50.24]$$

$$\Delta x = 20.09\,\alpha \approx 20\alpha$$

$$\Delta x = 20\alpha$$

64. An object is moving along x-axis. If its position x(t) (in meter) at any time t (in s) is given by the following graph, then the object is at rest about



(a) t = – 1 s (b) t = 0 s

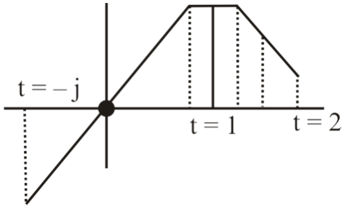
(c) t = 1 s (d) t = 2 s

TS EAMCET 28.09.2020, Shift-II

Ans. (c) : An object is moving along x-axis. If its position x (t) in meter at any time + (in sec) is given by the following graph. Then the object is at rest about t=1sec

@apna_pdf

Because at t = 1sec position of object is not changing.



65. A person on bike is moving along a horizontal circular path of radius 134 feet a constant speed of 72 km/hr. The angle of inclination of the bike with horizontal plant will be

(a) 30^o (b) 45^o

(c) 60^o (d) $\tan^{-1}\left(\frac{36}{67}\right)$

Tripura-2020

Ans. (b) : Radius of circular path

r = 134 ft

= 134 × 0.3045 m = 40.84 meter

Velocity V = 72 km/hr

$$= \frac{72\times1000}{3600} = 20 \text{ m/sec}$$

The angle of inclination

$$\because \tan\theta = \frac{V^2}{rg}$$

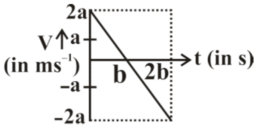
$$\tan\theta = \frac{(20)^2}{40.84\times9.8} = \frac{400}{403.08} = 0.9996$$

$\tan\theta \simeq 1$

$\theta = \tan^{-1}(1) = 45°$

Angle of inclination (θ) = 45°

66. When a small object is thrown vertically upward its velocity versus time graph is represented as follows



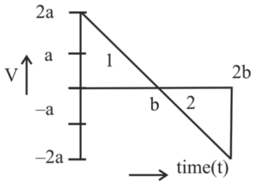
The maximum height it can reach is

(a) $\frac{a^2}{b}$ (b) $\frac{b^2}{a}$

(c) 2ab (d) ab

Tripura-2020

Ans. (c) :



$$\frac{ds}{dt} = v$$

ds = vdt

ds = area under the graph

$$ds_1 = \frac{1}{2}\times b\times 2a = ab$$

$$ds_2 = \frac{1}{2}\times b\times -2a = -ab$$

displacement $= ds_1 + ds_2$

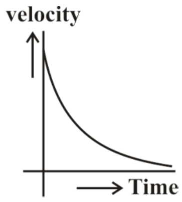
= ab – ab = 0

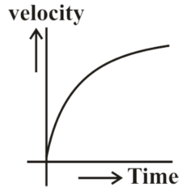
(Height) distance = $(ds_1) + |ds_2|$

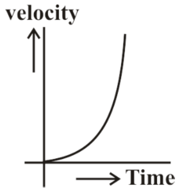
= ab + |–ab|

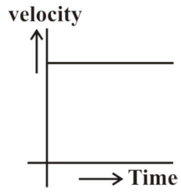
= ab + ab = 2ab

67. The graph which represents the velocity time dependence of a solid descending in a viscous sodium is

(a)


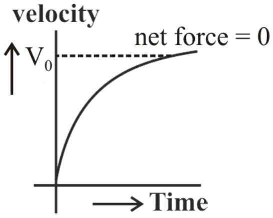
(b)


(c)


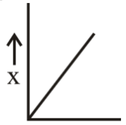
(d)


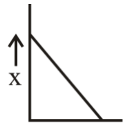
Tripura-2020

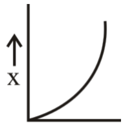
Ans. (b) : Initially the velocity of the body falling in a viscous fluid increases but after sometimes, the body moves with a constant velocity known as terminal velocity.

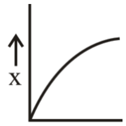


68. The velocity (v) of a body moving along the positive x direction varies with displacement (x) from the origin as $v = k\sqrt{x}$, where k is a constant. Then which of the following x–t graph is correct.

(a)


(b)


(c)


(d)


Assam CEE-2020

Ans. (c) : Given velocity displacement function

$$v = k\sqrt{x} \Rightarrow \frac{dx}{dt} = k\sqrt{x}$$

$$\int\frac{dx}{\sqrt{x}} = \int k dt$$

@apna_pdf

$$2\sqrt{x} = kt$$

$$t = \frac{2\sqrt{x}}{k}$$

$$t^2 = \frac{4x}{k^2}$$

i.e. $y^2 = 4ax$………which is equation of parabola.

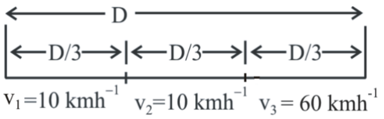
69. A car travels 1/3 of the distance on a straight road with a velocity of 10 km h^{-1} next 1/3 of the distance with velocity 20 km h^{-1} and the last 1/3 of the distance with velocity 60 km h^{-1}. The average velocity of the car in the whole journey is

(a) 18 km h^{-1} (b) 30 km h^{-1}

(c) 36 km h^{-1} (d) 90 km h^{-1}

Assam CEE-2020

Ans. (a):



$$\because \text{Average velocity} = \frac{\text{total distance}}{\text{total time}}$$

$$\text{Average velocity} = \frac{D}{\left(\frac{D/3}{10}+\frac{D/3}{20}+\frac{D/3}{60}\right)}$$

$$= \frac{D}{\frac{D}{3}\times\frac{1}{10}\left(1+\frac{1}{2}+\frac{1}{6}\right)} = \frac{30\times 6}{6+3+1} = \frac{30\times 6}{10} = 18\,\text{km}\,\text{h}^{-1}$$

70. The distance x covered by a particle in one dimensional motion varies with time t as $x^2 = at^2 + 2bt + c$. If the acceleration of the particle depends on x as x^{-n}, where n is an integer, the value of n is …… .

JEE Main-09.01.2020, Shift-I

Ans. (3) : $x^2 = at^2 + 2bt + c$

On differentiating both sides with respect to t, we get

$$2x\frac{dx}{dt} = 2at + 2b$$

$$xv = at + b$$

Again differentiating with respect to 't' we get

$$x\frac{dv}{dt} + v\frac{dx}{dt} = a$$

$$x.a + v.v = a$$

$$xa + v^2 = a$$

$$xa = a - v^2 = a - \left(\frac{at+b}{x}\right)^2$$

$$a = \frac{ax^2 - (at+b)^2}{x^3}$$

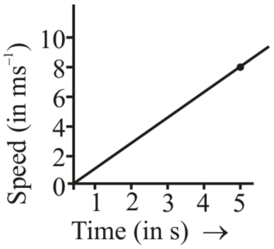
$$a \propto \frac{1}{x^3} \Rightarrow \boxed{a \propto x^{-3}} \quad \ldots(i)$$

$\because$ $a \propto x^{-n}$ (as given in question)

Thus, on comparing with equation (i)

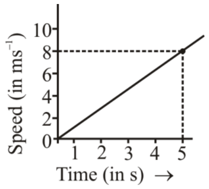
$n = 3$

71. The speed versus time graph for a particle is shown in the figure. The distance travelled (in metre) by the particle during the time interval t=0 s to t=5 s will be …………



JEE Main-04.09.2020, Shift-II

Ans. (20):

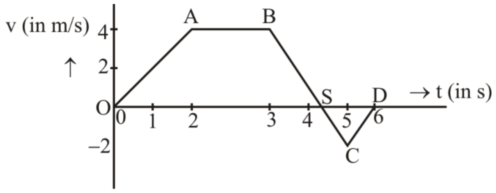


Distance = Area under speed – time graph

$$= \frac{1}{2}\times 5\times 8$$

$$= 20 \text{ m}$$

72. The v-t graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 s. The total distance covered by the body in 6 s is

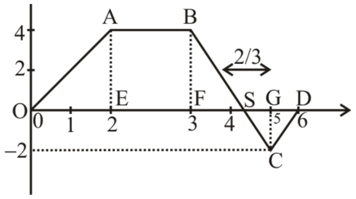


(a) $\frac{37}{3}$ m (b) 12 m

(c) 11 m (d) $\frac{49}{4}$ m

JEE Main-05.09.2020, Shift-II

Ans. (a) :



Distance cover by the body in 6 sec is–

= Area of ΔAOE + Area of rectangle ABFE+ Area of ΔBSF + Area of ΔSGC + Area of ΔGCD

$$= \frac{1}{2}(2\times 4) + (1\times 4) + \frac{1}{2}\times 4\times\left(\frac{4}{3}\right) + \frac{1}{2}\times 2\times\left(\frac{2}{3}\right) + \frac{1}{2}\times 2\times 1$$

$$= 4 + 4 + \frac{8}{3} + \frac{2}{3} + 1 = \frac{37}{3}\text{ m}$$

@apna_pdf

73. A person sitting in the ground floor of a building notices through the window of height 1.5m, a ball dropped from the roof of the building crosses the window in 0.1 s. What is the velocity of the ball when it is at the topmost point of the window? ($g = 10\ m/s^2$)

(a) 15.5 m/s (b) 14.5 m/s
(c) 4.5 m/s (d) 20 m/s

[NEET (Oct.) 2020]

Ans. (b) : Given, $g = 10 m/s^2$

$s = 1.5m$

$t = 0.1$ Second

From equation of motion,

$$s = ut + \frac{1}{2}gt^2$$

$$1.5 = u(0.1) + \frac{1}{2} \times 10 \times (0.1)^2$$

$$1.5 = (0.1)u + 5 \times 0.01$$

$$1.5 = (0.1)u + 0.05$$

$$u = \frac{1.45}{0.1} = 14.5\ m/s$$

74. A particle starts from the origin with an initial velocity $\vec{u} = (3.0\hat{j})m/s$ and a constant acceleration $\vec{a} = (-0.5\hat{i} - 1.0\hat{j})m/s^2$. The velocity of the particle when it reaches its maximum y coordinate is:

(a) $2\hat{i}$ (b) $-1.5\hat{i} + 1.5\hat{j}$
(c) $-1.5\hat{i}$ (d) $1.5\hat{i} + 1.0\hat{j}$

TS EAMCET 29.09.2020, Shift-II

Ans. (c) : $\vec{u} = (3.0\hat{j})m/s$

$\vec{a} = (-0.5\hat{i} - 1.0\hat{j})m/s^2$

This can be treated as 2 motions

One is x directions and other is y direction

y direction–

$$s_y = u_y t + \frac{1}{2}a_y t^2$$

Let s_y be the displacement in y-direction ,

$u_y = 3$ m/sec, $a_y = -1$ m/sec^2

$$\therefore \quad s_y = 3t - \frac{t^2}{2}$$

$v_y = u_y + a_y t$

$= 3 + (-1)t$

$= (3 - t)$ m/s

y component will be maximum, when $\frac{ds_y}{dt}$ or v_y is zero.

$v_y = 0 \Rightarrow 3 - t = 0$

$t = 3$

Similarly is x-direction,

$u_x = 0$, $a_x = -0.5$ m/sec^2

$v_x = u_x + a_y t$

$v_x = 0 + (-0.5)t$

$v_x = -0.5t$

Now at t = 3 sec

$v_x = -0.5 \times 3 = -1.5$ m/sec

Velocity vector $\vec{v} = v_x\hat{i} + v_y\hat{j} = -1.5\hat{i} + 0\hat{j}$

$\vec{v} = -1.5\hat{i}$ m/sec

75. An object is moving in a plane and its trajectory $\vec{r}(t)$ (in meter) is given by, $\vec{r}(t) = (3t^2 + 2t)\hat{i} + 2t\hat{j}$, where t is time (in second). The angle that the velocity vector makes with the X-axis at t = 0.

(a) 0° (b) 30°
(c) 45° (d) 60°

TS EAMCET 29.09.2020, Shift-II

Ans. (c) : Trajectory of an object–

$$\vec{r}(t) = (3t^2 + 2t)\hat{i} + 2t\hat{j}$$

$$\text{velocity, } \vec{v} = \frac{d\vec{r}}{dt} = (6t + 2)\hat{i} + 2\hat{j}\ m/s$$

$$\vec{v} = \underbrace{(6t+2)\hat{i}}_{v_x} + \underbrace{2\hat{j}}_{v_y}$$

Let θ is that angle which makes with X –axis,

at t = 0

$$\because \tan\theta = \frac{v_y}{v_x} = \frac{2}{6t + 2}$$

At t = 0,

$$\tan\theta = \frac{2}{0 + 2} = 1 = \tan 45^\circ$$

$$\theta = 45^\circ$$

76. A car travels from point A to point B at a speed 40 km/h. The car then returns from B to A at a speed 60 km/h. The average speed for the round trip is :

(a) 50 km/h (b) 24 km/h
(c) 52 km/h (d) 48 km/h

TS EAMCET 28.09.2020, Shift-II

Ans. (d) : A car travels from A to B at a speed 40 km/h and returns 60 km/h.

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{2 \times 40 \times 60}{40 + 60}$$

$$= \frac{2 \times 2400}{100}$$

$= 48$ km/h

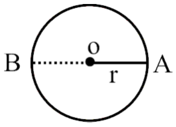
77. Starting from a point on circumference of a circle of radius 'r', a person moves to a point which is diametrically opposite its initial position. The distance travelled and displacement are respectively

(a) 2πr, 0 (b) πr, 2r
(c) 2r, 2πr (d) 2r, πr

AP EAMCET-25.09.2020, Shift-II

@apna_pdf

Ans. (b) :



According to question let a person stand initially at point A and he travels from A to B on circle which is diametrically opposite its initial position and has radius r.

So,

Distance (D) travelled by person = Distance along circumference from A to B.

$$D = \frac{2\pi r}{2} = \pi r$$

and Displacement = Distance along diameter (AB)

Displacement = AB = 2r

78. The displacement is given by $x = 2t^2 + t + 5$, the acceleration at t = 2s is

(a) 4 m.s^{-2} (b) 8 m.s^{-2}

(c) 10 m.s^{-2} (d) 15 m.s^{-2}

AP EAMCET-07.10.2020, Shift-I

Ans. (a) : Given,

Displacement $(x) = 2t^2 + t + 5$

Differentiating the above equation,

$$v = \frac{dx}{dt} = 4t + 1 + 0$$

$$\frac{dx}{dt} = 4t + 1 \qquad \text{....(i)}$$

Again, differentiating the equation (i)

$$a = \frac{d^2x}{dt^2} = 4 \times 1$$

$$\frac{d^2x}{dt^2} = a = 4\text{m/s}^2 \ \text{ at } t = 2\text{s}$$

$a = 4 \text{ m/s}^2$

79. The displacement (r) of a particle varies with time (t) according to the relation $x = \frac{a}{b}(1 - e^{-bt})$. Then

(a) at t = 1/b, the displacement will be $(1–e^{-1})$

(b) at t = 0, velocity of the particle is 'ab'

(c) maximum displacement of the particle is $\frac{a}{b}$

(d) none of the above statement are correct

Assam CEE-2020

Ans. (d) : Given,

$$x = \frac{a}{b}(1 - e^{-bt})$$

Then,

(a) at $t = \frac{1}{b}$

$$x = \frac{a}{b}(1 - e^{-1})$$

So, it is wrong statement.

(b) at t = 0 $v = \frac{dx}{dt} = \frac{a}{b}(0 - (-b)e^{-bt})$

$= a\, e^{-bt} \,|\text{ at t=0}$

$= a\, e^{-0}$

$= a \times 1$

So, it is also wrong statement

(c) For maximum or minimum

$$\frac{dx}{dt} = 0 \Rightarrow \frac{a}{b}\left(0 + b.e^{-bt}\right)$$

$= ae^{-bt} = 0$

$a \neq 0$

Then, $e^{-bt} = 0$

if $t \to \infty$

$$\frac{d^2x}{dt^2} = abe^{-bt} \,|\text{ at } t \to \infty$$

$= ab\, e^{-\infty} = 0$

Neither minima nor maxima at $t \to \infty$

Hence, option (d) is correct answer.

80. A particle is moving along the Y-axis. The position of the particle from the origin as a function of time (t) is given as $y(t) = 10\ te^{-2t}$. How far is the particle from the origin when it stops momentarily? (y is given in units of metre and t is in units of second)

(a) 5 m (b) 5e m

(c) $\frac{5}{e}$m (d) 10 m

TS-EAMCET-10.09.2020, Shift-2

Ans. (c) : Given as,

$$y = 10te^{-2t}$$

$$v = \frac{dy}{dt} = 10\left[t\left(e^{-2t}\right)(-2) + e^{-2t}\right]$$

$$v = 10\left[e^{-2t}(1 - 2t)\right]$$

When body stops then, v = 0

$0 = 10\,[e^{-2t}(1 – 2t)]$

$e^{-2t}(1 – 2t) = 0$

$1 – 2t = 0$

$t = \frac{1}{2}\text{sec}$

∴ $y = 10te^{-2t}$

$$= 10 \times \frac{1}{2} \times e^{-2\times\frac{1}{2}}$$

$$y = 10 \times \frac{1}{2} \times e^{-1} = \frac{5}{e}\text{m}$$

81. An airplane flies 400 m north and 300 m south and flies 1200 m upwards, then net displacement is

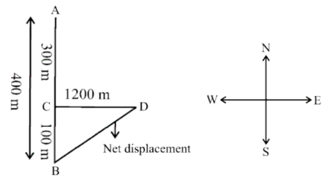
(a) 1400 m (b) 1500 m

(c) 1200 m (d) 1100 m

AP EAMCET (17.09.2020) Shift-I

@apna_pdf

Ans. (c) :



According to the image
AB = 400 m
AC = 300 m
BC = 100 m
CD = 1200 m

$\therefore$ Net Displacement = $\sqrt{(1200)^2+(100)^2}$

$= 1204 \approx 1200$ m

82. The displacement of a particle moving with uniform acceleration in time t is given by s = 30t + 5t^2, its initial velocity is

(a) 35 ms^{-1} (b) 30 ms^{-1}
(c) 40 ms^{-1} (d) 42 ms^{-1}

AP EAMCET (23.09.2020) Shift-I

Ans. (b) : According to the equation given in question

$s = 30t + 5t^2$

$\therefore \quad v = \dfrac{ds}{dt} = 30+10t$

For initial velocity

$t = 0,\ v = u$

$\boxed{u = 30 m/s}$

83. A moving body is covering distances which are proportional to square of the time. Then the acceleration of the body is

(a) constant but not zero (b) increasing
(c) zero (d) decreasing

MHT-CET 2020

Ans. (a) : Given,

$s \propto t^2$

$s = kt^2$ where, k = Constant

$v = \dfrac{ds}{dt} = 2kt$

Acceleration of the body-

$\dfrac{d^2s}{dt^2} = 2k \qquad \left(\because\ a = \dfrac{dv}{dt} = \dfrac{d^2s}{dt^2}\right)$

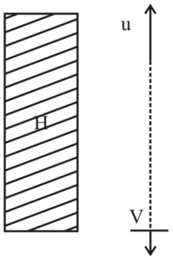
Thus, the acceleration of the body is constant but not zero.

84. From the top of a tower of height 'H' a body is thrown vertically upwards with a speed 'u'. Time taken by the body to reach the ground is '3' times the time taken by it to reach the highest point in its path. Then the speed u is

(a) $\sqrt{gH}$ (b) $\sqrt{\dfrac{gH}{2}}$
(c) $\sqrt{\dfrac{2gH}{3}}$ (d) $\sqrt{\dfrac{gH}{3}}$

AP EAMCET (Medical)-24.04.2019, Shift-I

Ans. (c) : The given situation can be shown as



Speed of the particle on reaching the ground,

$v = \sqrt{u^2+2gh}$

Also, $v = u + at$

$\sqrt{u^2+2gH} = -u+gt$ (Taking downward direction positive)

$t = \dfrac{u+\sqrt{u^2+2gH}}{g}$ …(i)

We know that time taken to reach the highest point is

$t = \dfrac{u}{g}$ …(ii)

From (i) and (ii) we get-

$\dfrac{u+\sqrt{u^2+2gH}}{g} = 3\times\dfrac{u}{g}$ (From question)

$u+\sqrt{u^2+2gH} = 3u$

$\sqrt{u^2+2gH} = 2u$

Squaring on both side,

$u^2 + 2gH = 4u^2$

$3u^2 = 2gH$

$u^2 = \dfrac{2gH}{3}$

$u = \sqrt{\dfrac{2gH}{3}}$

85. A particle first accelerates from rest and then retards to rest during the time interval of 8 s. If the retardation is 3 times the acceleration, then the time for which it accelerated is

(a) 2 s (b) 3 s
(c) 4 s (d) 6 s

AP EAMCET-24.04.2019, Shift-II

Ans. (b) : Let time of acceleration t

Retardation time = 8 – t

Total time = 8 sec

Let V_1 be velocity after acceleration-

So acceleration be a

$V_1 = u + at \quad \{u = 0\}$

$V_1 = at$ ……… (i)

None Retardation = 3a (given)

So, $V = V_1 - 3a\,(8 - t)$

$V_1 = 3a\,(8 - t)$ (V = 0) at body comes to rest

at = 3a(8–t) put V_1 from equation (i)

$t = 24 - 3t$

t = 6 second

@apna_pdf

86. Three particles A, B and C simultaneously start from the origin. Particle A moves with a velocity 'a' along X-axis, particle B moves with a velocity 'b' along Y-axis and particle C moves with a velocity 'c' in the X-Y plane along the straight line x = y. The magnitude of 'c' so that all the three particles always remain collinear is

(a) $a+b$ (b) $\sqrt{ab}$

(c) $\frac{ab}{a+b}$ (d) $\frac{\sqrt{2}\,ab}{a+b}$

AP EAMCET-23.04.2019, Shift-II

Ans. (d) : Let $V_1 = a$ and $V_2 = b$, $V_3 = c$

Three points are,

A(a, 0), B(0, b) and $C\left(\frac{c}{\sqrt{2}}, \frac{c}{\sqrt{2}}\right)$ these are collinear

Then slop are equal AB = AC

$$\frac{y_2-y_1}{x_2-x_1} = \frac{y_3-y_1}{x_3-x_1} \qquad \text{(equal slopes)}$$

$$\frac{b-0}{0-a} = \frac{\frac{c}{\sqrt{2}}-0}{\frac{c}{\sqrt{2}}-a}$$

$$\frac{bc}{\sqrt{2}} - ab = -\frac{ac}{\sqrt{2}}$$

$$\frac{c(a+b)}{\sqrt{2}} = ab$$

$$\therefore \quad c = \frac{\sqrt{2}ab}{(a+b)}$$

87. A particle is moving with speed $v = b\sqrt{x}$ along positive X-axis. Calculate the speed of the particle at time t = τ (assume that the particle is at origin at t =0).

(a) $\frac{b^2\tau}{4}$ (b) $\frac{b^2\tau}{2}$

(c) $b^2\tau$ (d) $\frac{b^2\tau}{\sqrt{2}}$

JEE Main-12.04.2019, Shift-II

Ans. (b) : Given, $v = b\sqrt{x}$

Differentiating the above equation with respect to time we get

$$\frac{dv}{dt} = \frac{d}{dt} b\sqrt{x}$$

$$a = \frac{b}{2\sqrt{x}}\frac{dx}{dt} = \frac{b}{2\sqrt{x}}v$$

$$a = \frac{b}{2\sqrt{x}} \times b\sqrt{x} = \frac{b^2}{2}$$

$$\boxed{a = \frac{b^2}{2}}$$

$\because$ v = u + at

Now, at x = 0, t = 0

Initial speed of particle is

$$u = \left[b\sqrt{x}\right]_{x=0} = b \times 0 = 0$$

When time (t) = τ,

$$v = u + at = 0 + \frac{b^2}{2}\tau$$

$$v = \frac{b^2\tau}{2}$$

88. The position of a particle as a function of time t, is given by $x(t) = at + bt^2 - ct^3$ where a, b and c are constants. When the particle attains zero acceleration, then its velocity will be

(a) $a+\frac{b^2}{2c}$ (b) $a+\frac{b^2}{4c}$

(c) $a+\frac{b^2}{3c}$ (d) $a+\frac{b^2}{c}$

JEE Main-09.04.2019, Shift-II

Ans. (c) : $x = at + bt^2 - ct^3$

$$\text{Velocity} \quad v = \frac{dx}{dt} = a + 2bt - 3ct^2$$

$$a = \frac{dv}{dt} = 2b - 6ct$$

Acceleration (a) = 0

$$2b - 6ct = 0$$

$$t = \frac{2b}{6c} = \frac{b}{3c}$$

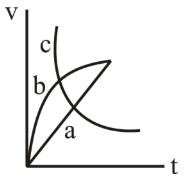
Putting the value of 't' in expression of velocity, we get

$$v = a + 2b \times \frac{b}{3c} - 3c\left(\frac{b}{3c}\right)^2$$

$$v = a + \frac{2b^2}{3c} - \frac{3cb^2}{9c^2} = a + \frac{2b^2}{3c} - \frac{b^2}{3c}$$

$$v = a + \frac{b^2}{3c}$$

89. A steel ball is dropped into long column of oil. Which of the following graph best describes the velocity of the ball with time?



(a) a (b) b

(c) c (d) None of the above

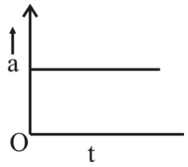
Assam CEE-2019

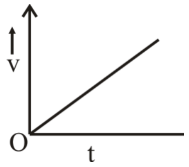
Ans. (b) : First ball will fall with increasing speed due to gravity, but as it speeds up backward dragging force i.e. viscous force increase. Eventually the viscous force is enough to balance the force of gravity, so the acceleration stops and the sphere reaches a constant terminal velocity.

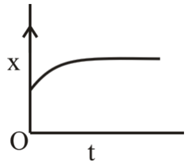
Thus, graph b describes the velocity of ball in best way.

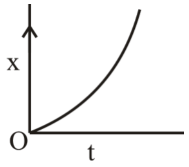
@apna_pdf

90. **A particle starts from origin O from rest and moves with a uniform acceleration along the positive X-axis. Identify all figures that correctly represent the motion qualitatively.**
(a = acceleration, v = velocity,
x = displacement, t = time)

(A)


(B)


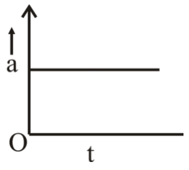
(C)


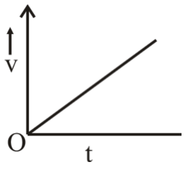
(D)


(a) (A)
(b) (B), (C)
(c) (A), (B), (C)
(d) (A), (B), (D)

JEE Main-08.04.2019, Shift-II

Ans. (d): Given initial velocity u = 0 and
Acceleration is constant
At time t :–
v = 0 + at
v = at

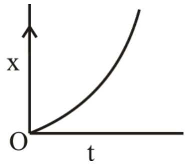




Also

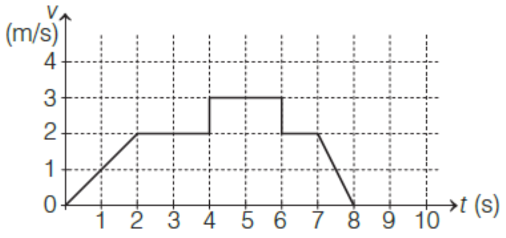
$$x = 0(t) + \frac{1}{2}at^2$$

$$x = \frac{1}{2}at^2$$



Graph (a), (b), and (d) are correct.

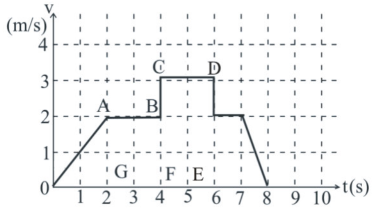
91. **A particle starts from the origin at time t=0 and moves along the positive X-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle at time t = 5s ?**



(a) 6 m
(b) 3 m
(c) 10 m
(d) 9 m

JEE Main-10.01.2019, Shift-II

Ans. (d) :



$\because \quad v = \frac{dx}{dt}$

dx = vdt
dx = Area under v – t curve given
we know,
Area under the v – t curve give the total distance fo the particle.
s = area under graph (time t = 0 to 5 sec)
s = area under graph (t = 0 to t = 2 sec) + area under graph (t = 2 to t = 4 sec) + area under graph (t = 4 to t = 5sec)

$$s = \frac{1}{2} \times 2 \times 2 + 2 \times 2 + 3 \times 1 = 9\,m$$

92. **A person travelling in a straight line moves with a constant velocity v_1 for certain distance 'x' and with a constant velocity v_2 for next equal distance. The average velocity v is given by the relation**

(a) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
(b) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
(c) $\frac{v}{2} = \frac{v_1 + v_2}{2}$
(d) $v = \sqrt{v_1 v_2}$

[NEET (Odisha) 2019]

Ans. (b) : Given,
Total distance = 2x

Time taken during 1st x distance = $\frac{x}{v_1}$

Time taken during 2nd x distance = $\frac{x}{v_2}$

Now, average velocity $= \frac{\text{total distance}}{\text{total time}}$

$$= \frac{2x}{\frac{x}{v_1} + \frac{x}{v_2}}$$

$$v = \frac{2}{\frac{1}{v_1} + \frac{1}{v_2}}$$

$$\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$$

93. **A ball is thrown in horizontal direction from a height of 80 m with initial speed v_0. The ball hits the ground with speed $3v_0$. The magnitude of v_0 is (Let g = 9.8 m/s^2)**

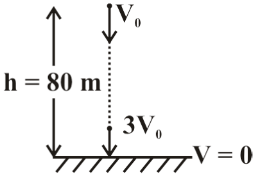
(a) 10 m/s
(b) 14 m/s
(c) 18 m/s
(d) 26 m/s

TS EAMCET 09.05.2019, Shift-I

@apna_pdf

Ans. (b) : Given,

$h = 80\text{m}, \; g = 9.8 \text{ m/s}^2$



Now, using $v^2 = u^2 - 2gh$.

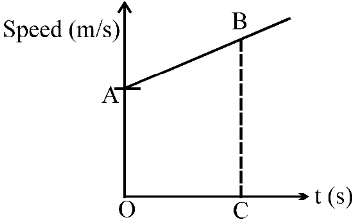
$$0 = (3V_0)^2 - 2 \times 9.8 \times 80$$

$$3v_0 = \sqrt{160 \times 9.8} = \sqrt{1568}$$

$$= 39.59$$

$$v_0 = 13.199 \approx 14 \text{ m/s}.$$

94. The speed versus time graph of moving particle is shown in the following figure If 'u' is the initial speed at t = 0, v is the speed at time t. 'a' is the acceleration and 's' is the distance covered in time 't', then total area OABC is best described using. (Assume O as origin).

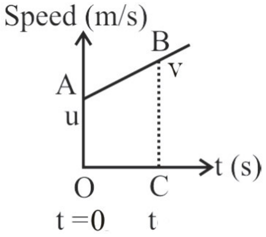


(a) $S = u + at$ (b) $S = ut + ½ at^2$

(c) $v^2 = u^2 + 2 as$ (d) $v = at$

TS EAMCET 09.05.2019, Shift-I

Ans. (b) :



Now, area under the graph,

$$A(OABC) = \frac{1}{2} \times (u + v) \times (t - 0)$$

$$A = \frac{1}{2}(u + v)t$$

$\therefore$ $v = u + at$

$$A = \frac{1}{2}(u + u + at)t$$

$$A = \frac{1}{2}. 2ut + \frac{1}{2}at^2$$

$$A = ut + \frac{1}{2}at^2$$

$$S = ut + \frac{1}{2}at^2$$

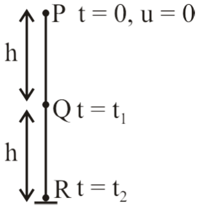
95. Points P, Q and R are in a vertical line such that PQ = QR. A ball at P is allowed to fall freely with zero initial speed. The ratio of the times of descent through PQ and QR is

(a) $1:(\sqrt{2}+1)$ (b) $1:(\sqrt{2}-1)$

(c) 1 : 2 (d) $1:\sqrt{2}$

TS EAMCET 08.05.2019, Shift-II

Ans. (b) :



Now, for P to Q.

$$h = 0 + \frac{1}{2}gt_1^2 \qquad \left\{ \begin{array}{l} \text{using,} \\ h = ut + \frac{1}{2}gt^2 \end{array} \right\}$$

$$t_1 = \sqrt{\frac{2h}{g}}$$

For P to R,

$$t_2 = \sqrt{\frac{2(2h)}{g}}$$

Time taken to descent PQ = $t_1 \sqrt{\frac{2h}{g}}$

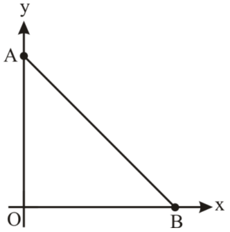
Time taken to descent QR = $t_2 - t_1 = \sqrt{\frac{2h}{g}}(\sqrt{2}-1)$

$\therefore$ Ratio of time descent through PQ and QR is

$$\frac{PQ}{QR} = \frac{1}{\sqrt{2}-1}$$

$$PQ : QR = 1 : (\sqrt{2}-1)$$

96. A and B are the ends of a ladder in contact with a vertical wall and the floor respectively as shown in the figure. Let u_B and v_A be the velocities of B and A in x and y direction respectively. At a time when the angle ABO is 60°, u_B = 1 m/s, then v_A in m/s is



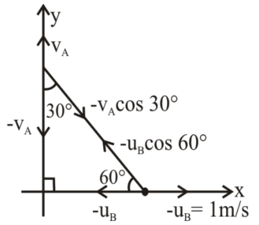
(a) $-\sqrt{3}$ (b) $-\frac{1}{\sqrt{3}}$

(c) $\frac{1}{\sqrt{3}}$ (d) $\sqrt{3}$

TS EAMCET 08.05.2019, Shift-I

@apna_pdf

Ans. (b) :



For the movement of ladder, component of v_A must be opposite to the component of u_B along ladder.

$$v_A \cos 30° = -u_B \cos 60°$$

$$v_A \frac{\sqrt{3}}{2} = -1 \times \frac{1}{2}$$

$$v_A = \frac{-1}{\sqrt{3}} \text{ m/s}$$

97. **Assertion:** The position-time graph of a uniform motion in one dimension of a body can have negative slope.

Reason: When the speed of body decreases with time, the position-time graph of the moving body has negative slope.

(a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c) If Assertion is true but Reason is false.
(d) If both Assertion and Reason are false.

AIIMS-26.05.2019(M) Shift-1

Ans. (c) : Negative slope of position-time graph represents that the body is moving towards the negative direction if the slope of the graph decrease with time. Thus, it represents the decrease in speed i.e. retardation in motion.

So, the constant negative slope of the position time graph cannot represent the decrease in speed. Therefore the reason is incorrect.

98. **Assertion:** The displacement-time graph of a body moving with uniform acceleration is a parabola.

Reason: The displacement is proportional to time for uniformly accelerated motion.

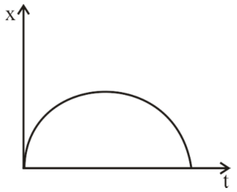
(a) If both Assertion and Reason are true and Reason is the correct explanation of assertion.
(b) If both Assertion and Reason are true but Reason is not the correct explanation of assertion.
(c) If Assertion is true but Reason is false.
(d) If both Assertion and Reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (c) :

Acceleration (a) = const.

$$\text{Displacement } (x) = ut + \frac{1}{2}at^2$$



This is an equation of parabola. Therefore, the displacement time-graph is a parabola.

If, $x \propto t$

$x = kt$

$$\text{Velocity, } v = \frac{dx}{dt} = k = \text{constant}$$

$$\text{Acceleration, } a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = 0$$

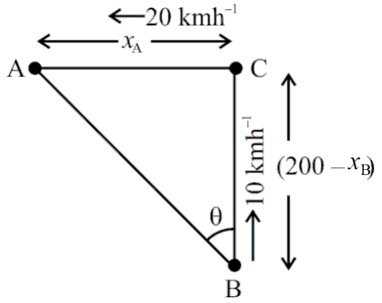
So, this is uniform motion in which only velocity will be constant

99. **Ship A is moving Westwards with a speed of 20 km h^{-1} and another ship B which is at 200 km South of A is moving Northwards with a speed of 10 km h^{-1}. The time after which the distance between them is shortest and the shortest distance between them respectively,**

(a) 4h, $80\sqrt{5}$ km
(b) $50\sqrt{2}$ h, $\sqrt{10}$ km
(c) $100\sqrt{2}$ h, $2\sqrt{10}$ km
(d) $80\sqrt{5}$ h, 4 km

AP EAMCET (21.04.2019) Shift-II

Ans. (a) : According to the question,



Let ship A travel x_A distance and ship B travel x_B distance in time t.

$$\text{So, } u_A = \frac{x_A}{t} \Rightarrow t = \frac{x_A}{20}$$

$$\text{and } u_B = \frac{x_B}{t} \Rightarrow t = \frac{x_B}{10} \Rightarrow \frac{x_A}{20} = \frac{x_B}{10} \Rightarrow x_A = 2x_B$$

$$\text{So, } AB = \sqrt{x_A^2 + (200 - x_B)^2}$$

$$= \sqrt{4x_B^2 + 40000 + x_B^2 - 400x_B}$$

$$= \sqrt{5x_B^2 - 400x_B + 40000}$$

Differentiate distance AB w.r.t. x_B for finding value of x_B,

$$\frac{d(AB)}{dx_B} = \frac{1}{2\sqrt{5x_B^2 - 400x_B + 40000}}(10x_B - 400) = 0$$

or $x_B = 40$ m

$$\text{So, } AB = \sqrt{5 \times 40^2 - 400 \times 40 + 40000}$$

$$AB = \sqrt{32000}$$

$$\text{or } AB = 80\sqrt{5}\text{km}$$

The time after which the distance AB is shortest,

$$t = \frac{x_A}{20} = \frac{x_B}{10} = \frac{40}{10} = 4\,\text{hr}.$$

@apna_pdf

100. Find the ratio of the distance travelled by a freely falling body during the first and third second of its fall.

(a) 1 : 3 (b) 3 : 5
(c) 1 : 5 (d) 2 : 3

J&K-CET-2019

Ans. (c) : Initial velocity of the body, u = 0
Distance covered in t^{th} second,

$$s_t = u + \frac{1}{2}g(2t-1)$$

$$\therefore \quad s_t = 0 + \frac{1}{2}g\,(2t-1) = \frac{1}{2}g(2t-1)$$

Distance travelled in first second, t = 1,

$$s_1 = \frac{1}{2}g(2\times1-1) = \frac{1}{2}g$$

Distance travelled in third second, t = 3,

$$s_3 = \frac{1}{2}g(2\times3-1) = \frac{5}{2}g$$

$$\therefore \quad s_1 : s_3 = 1 : 5$$

101. A particle covers half of the circle of radius r. Then the displacement and distance of the particle are respectively

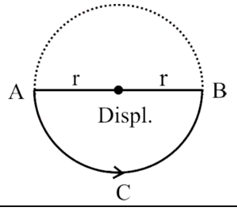
(a) $2\pi r, 0$ (b) $2r, \pi r$
(c) $\frac{\pi r}{2}, 2r$ (d) $\pi r, r$

VITEEE-2019

Ans. (b) : When a particle covers half of a circle of radius r, then displacement is AB = diameter = 2r
And

$$\text{The distance of the particle ACD} = \frac{\text{Perimeter of circle}}{2}$$

$$= \frac{2\pi r}{2} = \pi r$$



102. A particle is revolving in a circle with increasing its speed uniformly. Which of the following is constant?

(a) Centripetal acceleration
(b) Tangential acceleration
(c) Angular acceleration
(d) None of these

HP CET-2018

Ans. (b) :
(a) Centripetal force is not constant centripetal force directly proportional to square of speed and speed is increasing uniformly.
(b) Tangential acceleration is constant because speed along the circular path increases uniformly. Only constant acceleration will give uniform increase of speed.
(c) Angular acceleration is also constant. Tangential acceleration is the product of angular acceleration and radius of circular path. If the particle is restricted to move in the circular path of constant radius, then Angular acceleration is constant.

103. Calculate the net force acting on a body of mass 10 kg moving with a uniform velocity of 2 ms^{-1}

(a) zero (b) 10 N
(c) 2 N (d) 20 N

HP CET-2018

Ans. (a) : mass of body (m) = 10kg
uniform velocity = 2m/s
We know,

$$a = \frac{dv}{dt}$$

$$a = \frac{d(2m/s)}{dt}$$

$$a = 0$$

So,

$$\text{Net force (F)} = m\times a = 10\times0 = 0$$

104. The displacement of a particle moving along a straight line is related to time as $\sqrt{x} = t - 3$ The displacement of the particle when its velocity is zero is

(a) 6m (b) 3m
(c) 9m (d) 0

Assam CEE-2018

Ans. (d): $\sqrt{x} = t-3$ ....(i)

$$x = (t-3)^2$$

$$\frac{dx}{dt} = v = 2(t-3) \text{ ....(ii)}$$

According to question,
When v = 0, Then from equation (ii)
t = 3 sec
Now, from equation (i) at t = 3 sec, displacement is zero.

105. The driver of a bus moving at an speed of 60 km/hr saw a man at a distance of 52 m from the bus. The driver stopped the car at a distance of 2 m from the man using brake. The time required to stop the bus is

(a) 18s (b) 12s
(c) 6s (d) 2s

Assam CEE-2018

Ans. (c) : u= 60 km/h

$$u = 60\times\frac{1000}{3600}$$

$$u = \frac{50}{3}m/s$$

$$v = 0$$

$$s = 50 \text{ m}$$

As we know,

$$v^2 = u^2 + 2as$$

@apna_pdf

$$0 = \frac{2500}{9} + 2a(50)$$

$$a = -\frac{25}{9}$$

Now, $v = u + at$

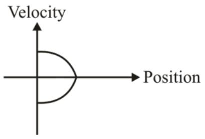
$$0 = \frac{50}{3} - \left(\frac{25}{9}\right)t$$

$$t = \frac{50}{3} \times \frac{9}{25}$$

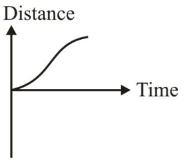
$t = 6$ s

106. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.

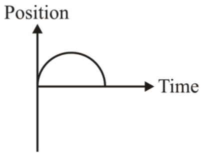
(a)



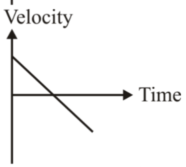
(b)



(c)



(d)



JEE Main 2018

Ans. (b) : Option (a), The velocity, position graph which is almost a semi circle. As per option (a) at t = 0 the position is zero.

As per this option at zero position the particle has either a positive velocity of a negative velocity but not a zero velocity.

- Option (b), The distance time graph which has a zero slope at t =0 and the slope initially increase and then decreases.

This indicates that at t = 0 the particle is at rest and its speed is zero.

- Option (c), The position time graph.

At t = 0 the particle is at zero and the graph has a positive slope. As the time increases the slope decreases, becomes zero and then negative. That means at t = 0 the particle has a positive velocity.

- Option (d), The velocity time graph and is straight line with a negative slope and intersecting the time axis and going even to the negative velocity.

At t =0 the particle has a positive velocity which decreases linearly with time.

107. A toy car with charge q moves on a frictionless horizontal plane surface under the influence of a uniform electric field E. Due to the force qE, its velocity increases from 0 to 6 m/s in one second duration. At that instant, the direction of the field is reversed. The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 seconds are respectively

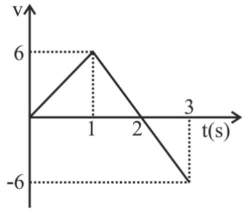
(a) 1 m/s, 3.5 m/s	(b) 1 m/s, 3 m/s
(c) 2 m/s, 4 m/s	(d) 1.5 m/s, 3 m/s

[NEET 2018]

Ans. (b) :

Total displacement = Area under the v-t curve

$$= \frac{1}{2} \times 2 \times 6 - \frac{1}{2} \times 1 \times 6 = 6 - 3 = 3\text{m}$$



$$\therefore \quad \text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{3}{3} \Rightarrow 1\text{m/s}$$

$$\text{Total distance travelled } = \frac{1}{2} \times 2 \times 6 + \frac{1}{2} \times 1 \times 6$$

$$= 6 + 3$$

$$= 9\text{m}$$

$$\therefore \quad \text{Average speed} = \frac{\text{Total path travelled}}{\text{Total time}}$$

$$= \frac{9}{3} = 3 \text{ m/s}$$

Hence,

Average velocity = 1 m/s

Average speed = 3 m/s

108. The equation of motion of a particle is given by $x(t) = 2t^3 + t^2 + 4t$. Then the average velocity of the particle between the time t = 3s to t = 5s is

(a) 100 m/s	(b) 110 m/s
(c) 90 m/s	(d) 140 m/s

TS EAMCET 02.05.2018, Shift-II

Ans. (b) : Given :

$$x(t) = 2t^3 + t^2 + 4t$$

We know that,

$$v = \frac{dx}{dt}$$

$$\int_3^5 v\,dt = \int_3^5 dx$$

$$v[t]_3^5 = [x]_3^5 = \left[2t^3 + t^2 + 4t\right]_3^5$$

$$v_{avg}\,[5 - 3] = [(250 + 25 + 20) - (54 + 9 + 12)]$$

$$v_{avg}\,2 = 295 - 75$$

$$v_{avg} = \frac{220}{2}$$

$$v_{avg} = 110 \text{ m/s}$$

109. The displacement of a body is given by $x = 4t + 5t^3$, where x is in meter and t is in second. The difference between the average velocity of the body in the time-interval t = 1 s to t = 2 s and its instantaneous velocity at t = 1 s is

(a) 20.0 m s^{-1}	(b) 22.5 m s^{-1}
(c) 27.0 m s^{-1}	(d) 39.0 m s^{-1}

AMU-2018

@apna_pdf

Ans. (a) : Given,

Displacement of the body (x) = 4t + 5t^3 …….(i)

At t = 1 sec,

$x_1 = 4 \times 1 + 5\,(1)^3 = 9$

and At t = 2 sec,

$x_2 = 4 \times 2 + 5 \times (2)^3 = 48$

∴ Displacement of the body from t = 1s to t = 2s

$\Delta x = x_2 - x_1 = 48 - 9 = 39$ m

$$\therefore v_{avg} = \frac{\Delta x}{\Delta t} = \frac{39}{2-1} = 39\,m/s$$

Differentiating eq^n (i) with respect to t,

$$x = 4t + 5t^3$$

$$\therefore \frac{dx}{dt} = v = 4 + 15t^2$$

Then, v_{inst} at t = 1s

$\therefore \quad v_{inst} = 4 + 15 \times (1)^2 = 19$ m/s

Thus, $v_{avg} - v_{inst} = 39 - 19 = 20$ m/s

110. The nearest star to our solar system is 4.3 light years away. The distance of this star in Parsec is (Mean distance between the earth and the sun = 1.5 × 10^{11} m and one light year = 9.46 × 10^{15} m)

(a) 1.3 (b) 8.0

(c) 13.0 (d) 3.3 × 10^4

AMU-2018

Ans. (a) : We know,

1 light year = 9.46 × 10^{15}m

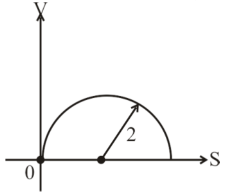
Then, 4.3 light year = 4.3 × 9.46 × 10^{15}m

and 1 parsec = 3.1 × 10^{16} m

$$\therefore 4.3 \text{ light year} = \frac{4.3 \times 9.46 \times 10^{15}}{3.1 \times 10^{16}} \text{parsec}$$

$$= \frac{1312.19}{1000} \text{ parsec} = 1.3 \text{ parsec}$$

111. The velocity displacement (v-s) graph shows the motion of particle moving in a straight line. Velocity-displacement graph is a circle of radius 2 m and centre is at (2, 0) m.



The value of acceleration for this particle at a point $\left(2-\sqrt{2}, \sqrt{2}\right)$ m will be ……….ms^{-2}.

(a) $\sqrt{2}$ (b) 4

(c) 2 (d) 3

AP EAMCET (23.04.2018) Shift-2

Ans. (a) :

∵ Curve is a circle with centre (2,0) and radius 2,

Equation of circle,

$(x-a)^2 + (y-b)^2 = r^2$

$(s-2)^2 + (v-0)^2 = 2^2$

$(s-2)^2 + v^2 = 4$

Differentiating with respect to t,

$$2(s-2)\frac{ds}{dt} + 2v\frac{dv}{dt} = 0$$

$$2(s-2)v + 2va = 0 \quad \left\{\therefore v = \frac{ds}{dt} \text{and } a = \frac{dv}{dt}\right\}$$

At $s = 2-\sqrt{2}$ and $v = \sqrt{2}$

$$2(2-\sqrt{2}-2)\sqrt{2} + 2 \times \sqrt{2}\,a = 0$$

$$-4 + 2\sqrt{2}\,a = 0$$

$$a = \frac{4}{2\sqrt{2}} = \frac{2}{\sqrt{2}}$$

So, $a = \sqrt{2}\,m/s^2$

112. A particle is moving along the X-axis such that its acceleration is proportional to the displacement from the equilibrium position and they are in the same direction. The displacement x(t) is given by

(a) $\sin\omega t, \omega > 0$

(b) $\sin\omega t + \cos\omega t, \omega > 0$

(c) $e^{\omega t}, \omega > 0$

(d) $e^{\omega t} + \sin\omega t, \omega > 0$

(e) $e^{\omega t} + e^{\omega^2 t}\omega_1 \text{ and } \omega_2 > 0$

Kerala CEE -2018

Ans. (c) : Given,

displacement = x(t)

$a \propto x(t)$ ...(i)

According to option (a),

$$x(t) = \sin\omega t, \omega > 0$$

$$u(t) = \frac{dx(t)}{dt} = \frac{d}{dt}\sin\omega t = \omega\cos\omega t \text{ and}$$

$$a = \frac{du(t)}{dt} = \frac{d}{dt}(\omega\cos\omega t) = -\omega^2\sin\omega t$$

Or $a = -\omega^2 x(t)$ ...(ii)

in the opposite direction

According to option (b),

$$x(t) = \sin\omega t + \cos\omega t, \omega > 0$$

$$\therefore \quad u(t) = \frac{dx(t)}{dt} = \omega\cos\omega t - \omega\sin\omega t$$

and $a = \dfrac{du(t)}{dt} = -\omega^2\sin\omega t - \omega^2\cos\omega t$

or $a = -(\omega^2\sin\omega t + \omega^2\cos\omega t)$ or $a = -\omega^2 x(t)$ ...(iii)

Thus, It also in opposite direction.

According to option (c),

$$x(t) = e^{\omega t}, \omega > 0$$

$$\therefore \quad u(t) = \frac{dx(t)}{dt} = \omega e^{\omega t}$$

and $a = \dfrac{du(t)}{dt} = \omega^2 e^{\omega t}$

or $a = \omega^2 x(t)$ ...(iv)

$a \propto x(t)$ in the same direction

@apna_pdf

According to option (d),

$$x(t) = e^{\omega t} + \sin\omega t \qquad \omega > 0$$

$$\therefore \quad u(t) = \frac{dx(t)}{dt} = \omega e^{\omega t} + \omega\cos\omega t$$

$$\text{and } a = \frac{du(t)}{dt} = \omega^2 e^{\omega t} - \omega^2\sin\omega t$$

$$\text{or} \quad a = \omega^2(e^{\omega t} - \sin\omega t) \qquad ...(v)$$

According to option (e),

$$x(t) = e^{\omega t} + e^{\omega^2 t}, \omega_1 \text{ and } \omega_2 > 0$$

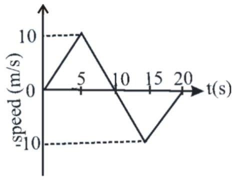
$$\therefore \quad u(t) = \frac{dx(t)}{dt} = \omega e^{\omega t} + 2\omega e^{\omega^2 t}$$

$$\text{and} \quad a = \frac{du(t)}{dt} = \omega^2 e^{\omega t} + 4\omega^2 e^{\omega^2 t}$$

$$\text{or} \quad a = \omega^2 e^{\omega t} + 4\omega^2 e^{\omega^2 t} \qquad ...(vi)$$

Hence, by comparing equation (ii), (iii), (iv), (v) and (vi) with Eq. (i) option (c) is best suited.

113. The one-dimensional motion of a point particle is shown in the figure. Select the correct statement.



(a) The total distance travelled by the particle is zero
(b) The total displacement of the particle is zero
(c) The maximum acceleration of the particle is $\frac{1}{2}\text{ms}^{-2.}$
(d) The total distance travelled by the particle at the end of 10s is 100 m
(e) At the fifth second, the acceleration of the particle is 2ms^{-2}

Kerala CEE -2018

Ans. (b) :

$$v = \frac{ds}{dt}$$

$$\int ds = \int vdt$$

Δs = Area under v-t curve

$$\Delta s = d_1 + d_2$$

$$\Delta s = \frac{1}{2}\times10\times10 - \frac{1}{2}\times10\times10$$

$$\therefore \quad \Delta s = 0$$

114. An athlete runs exactly once around a circular track of length 500 m. The runner's displacement in the race is

(a) 50 m (b) 5 m
(c) 0.5 m (d) 0 m

J&K-CET-2018

Ans. (d) : Displacement is known as the distance between initial position and final position. In a circular track, the initial and final position of the athlete is same. The total distance covered is 500 m, but the net displacement is zero. So, total displacement is zero.

115. A car starts from rest with a constant acceleration of 5 ms^{-2}. At the same time a bus travelling with uniform velocity of 50 ms^{-1} overtakes and passes the car. The distance through which the car again overtakes the bus is:

(a) 250m (b) 500m
(c) 750m (d) 1000m

Assam CEE-2017

Ans. (d): Given, s = 50t, u = 0, a = 5m/s^2

Distance covered by bus will be equal to distance covered by car.

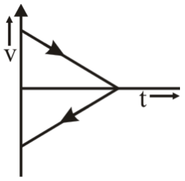
$$\because \quad s = ut + \frac{1}{2}at^2 \qquad .....(i)$$

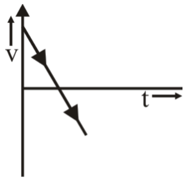
$$50t = 0\times t + \frac{1}{2}5t^2$$

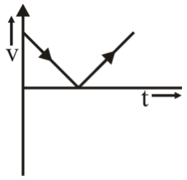
$$t = 20 \text{ sec}$$

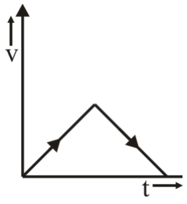
Distance = speed × time = 50 × 20 = 1000m

116. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time?

(a)


(b)


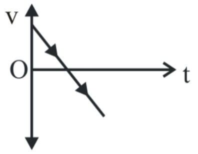
(c)


(d)


JEE Main 2017

Ans. (b) : $v = u - gt = u - 10t$ ($\because g = 10$ m/s^2)

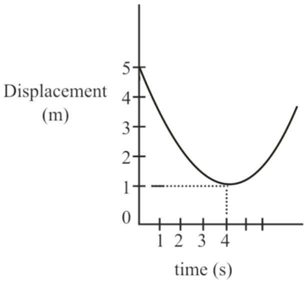
v – t graph



y = u – 10x (straight line)
y = c + m x
compare–
Slope (m) = –10 (–ve)
c = u (+ve)

117. The displacement of a particle moving along x-axis versus time is given in the figure below: The average velocity (V_{avg}) of the particle in the first four seconds and the velocity V of it at t=4s are

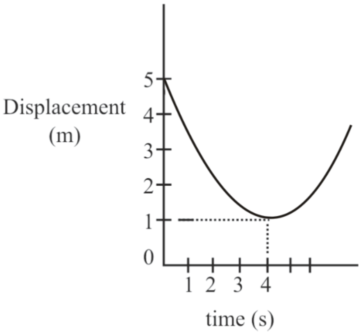
@apna_pdf



(a) $V_{avg} = -1m/s, V = -1m/s$
(b) $V_{avg} = 1m/s, V = 1m/s$
(c) $V_{avg} = 1m/s, V = 0m/s$
(d) $V_{avg} = -1m/s, V = 0m/s$

TS EAMCET(Medical)-2017

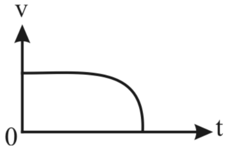
Ans. (d) : Let us consider
As t = 0, particle is at a position 5m,
and at t = 4s particle is at a position 1m.
Displacement of particle (s) = 1 – 5 = – 4 m
time taken (t) = 4s

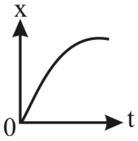


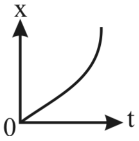
Average velocity $(V_{avg}) = \frac{s}{t} = \frac{-4}{4} = -1m/s$

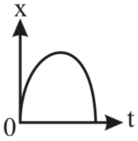
At a slope of displacement time graph gives the velocity of particle at that instant.
slope of the graph is zero at t = 4s
then, the velocity is zero at t = 4s
Hence, $V_{av} = -1m/s$, V = 0 m/s

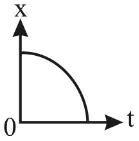
118. Consider one dimensional motion of a particle. Velocity v versus time t graph is shown. Which graph is most appropriate for displacement versus time t?



(a)


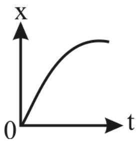
(b)


(c)


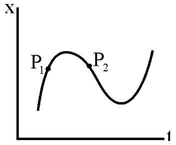
(d)


UPSEE - 2017

Ans. (a) : Initial velocity is constant so slope of x-t graph is constant and finite. Eventually the velocity becomes zero, so the slope of the x-t graph becomes zero.



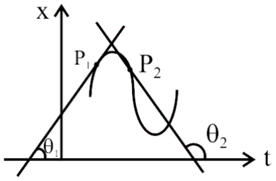
119. The x-t plot shown in the figure below describes the motion of the particle, along x-axis, between two positions A and B. The particle passes through two intermediate points P_1 and P_2 as shown in the figure.



(a) The instantaneous velocity is positive as P_1 and negative at P_2.
(b) The instantaneous velocity is negative at both P_2.
(c) The instantaneous velocity is negative at P_1 and positive at P_2.
(d) The instantaneous velocity is positive at both P_1 and P_2.
(e) The instantaneous velocity is always positive.

Kerala CEE - 2017

Ans. (a) :



$$\because \quad v = \frac{dx}{dt} = \text{slope of } x-t \text{ plot}$$

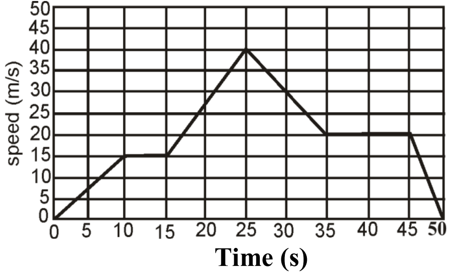
$$v_{P_1} = \tan\theta_1 = \left(\frac{dx}{dt}\right)_{P_1} \text{ is positive} \Rightarrow v_{P_1} \text{ is postive}$$

$$(\because \theta_1 < 90°, \tan\theta_1 = +ve)$$

$$v_{P_2} = \tan\theta_2 = \left(\frac{dx}{dt}\right)_{P_2} \text{ is negative} \Rightarrow v_{P_2} \text{ is negative}$$

$$(\because \theta_2 > 90°, \tan\theta_2 = -ve)$$

120. The following figure gives the movement of an object. Select the correct statement from the given choices.

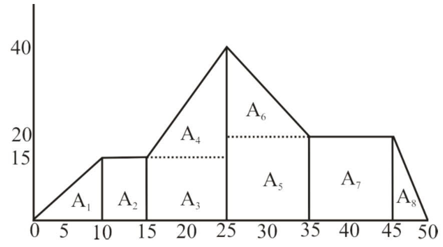


@apna_pdf

(a) The total distance travelled by the object is 975m
(b) The maximum acceleration of the object is $2m/s^2$
(c) The maximum deceleration happened between 25th and 35th seconds
(d) The object was at rest between 10th and 15th seconds
(e) At 40th second, the speed of object was decelerating

Kerala CEE - 2017

Ans. (a) : Total distance travelled = Area under s – t graph



∴ Total distance travelled

$$= A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7 + A_8$$

$$= \frac{1}{2}\times 10\times 15 + (15-0)(15-10) + (15-0)(25-15)$$

$$+ \frac{1}{2}\times(25-15)(40-15) + (20-0)(35-25)$$

$$+ \frac{1}{2}\times(40-20)(35-25) + (20-0)(45-35)$$

$$+ \frac{1}{2}(20-0)\times(50-45)$$

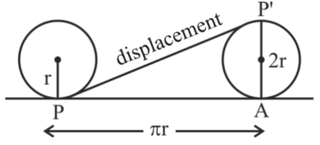
$$= 75 + 75 + 150 + 125 + 200 + 100 + 200 + 50 = 975 \text{ m}$$

121. Consider a point P, the contact point of a wheel of radius r on the ground which rolls on the ground without slipping. What is the displacement of point P, when the wheel completes half rotation?

(a) 2 r
(b) π r
(c) $r\sqrt{\pi^2+4}$
(d) $r\sqrt{\pi^2+2}$

SCRA-2012

Ans. (c) : When the wheel rolls on the ground without slipping and completes half rotation, point P takes new position as P' as shown in figure.



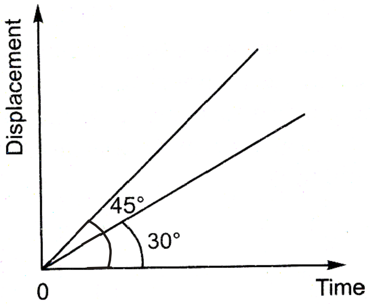
Horizontal displacement = πr
Vertical displacement = 2r
Thus, displacement of the point P when wheel complete half rotation.

$$S = \sqrt{(\pi r)^2 + (2r)^2}$$

$$S = \sqrt{\pi^2 r^2 + 4r^2}$$

$$S = r\sqrt{\pi^2 + 4}$$

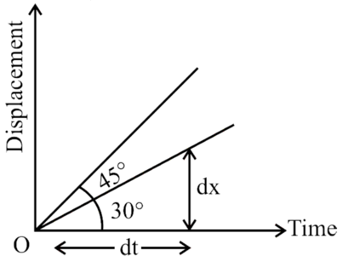
122. The displacement time graph of two moving particles make angles of 30° and 45° with the X-axis. The ratio of their velocities is :



(a) $\sqrt{3}:2$
(b) 1 : 1
(c) 1 : 2
(d) $1:\sqrt{3}$

Karnataka CET-2011

Ans. (d) : By the definition, the slope of displacement time graph is velocity.



i.e. $v = \frac{dx}{dt} = \tan\theta$

So, $\frac{v_1}{v_2} = \frac{\tan\theta_1}{\tan\theta_2} = \frac{\tan 30^\circ}{\tan 45^\circ}$

$$\frac{v_1}{v_2} = \frac{1/\sqrt{3}}{1}$$

$$\frac{v_1}{v_2} = \frac{1}{\sqrt{3}}$$

123. For ordinary terrestrial experiments, the observer in an inertial frame in the following cases is :

(a) A child revolving in a giant wheel
(b) A driver in a sports car moving with a constant high speed of 200 kmh^{-1} on a straight road
(c) The pilot of an aeroplane which is taking off
(d) A cyclist negotiating a sharp curve

Karnataka CET-2006

Ans. (b) : Every body that is undergo an inertial frame of reference, maintains its position if rest or of motion until the body is acted upon by any external force.

In option (b), driver is driving the car with a constant velocity of 200 kmh^{-1} so, it comes in an inertial frame of reference.

- a and d options experience centripetal acceleration.
- Option (c) experience linear acceleration in the frame of reference.

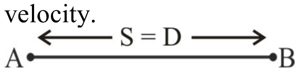
@apna_pdf

124. A body is moving along a straight line path with constant velocity. At an instant of time the distance travelled by it is S and its displacement is D, then

(a) $D < S$ (b) $D > S$
(c) $D = S$ (d) $D \leq S$

J&K CET- 2008

Ans. (c) : The body is moving in straight line with uniform velocity.



So, at any instant of the time distance covered by the body is always equal to displacement.

$D = S$

125. A particle starts from rest and experiences constant acceleration for 6 seconds. If it travels a distance d_1 in the first two seconds, a distance d_2 in the next two seconds and a distance d_3 in the last two seconds, then

(a) $d_1 : d_2 : d_3 = 1 : 1 : 1$
(b) $d_1 : d_2 : d_3 = 1 : 2 : 3$
(c) $d_1 : d_2 : d_3 = 1 : 3 : 5$
(d) $d_1 : d_2 : d_3 = 1 : 5 : 9$

J&K CET- 2003

Ans. (c) : From the second equation of motion,

$$s = ut + \frac{1}{2}at^2$$

Here u = 0

So, $s = 0 + \frac{1}{2}at^2 = \frac{1}{2}at^2$

Now according to the question,

$$d_1 = \frac{1}{2}a(2)^2 = 2a$$

$$d_1 + d_2 = \frac{1}{2}a(4)^2 = 8a$$

$$d_2 = (d_1 + d_2) - d_1 = 8a - 2a = 6a$$

$$d_1 + d_2 + d_3 = \frac{1}{2}a(6)^2$$

$$\because d_3 = (d_1 + d_2 + d_3) - (d_1 + d_2)$$

$$d_3 = \frac{1}{2}a(6)^2 - 8a = 10a$$

Hence, $d_1 : d_2 : d_3 = 2a : 6a : 10a$
$= 1 : 3 : 5$

126. When a particle returns to its initial point, its

(a) Displacement is zero
(b) Average velocity is zero
(c) Distance is zero
(d) Average speed zero

J&K-CET-2014

Ans. (a, b) : When initial and final positions are same then displacement and average velocity both are zero.

$$\text{Average velocity } \vec{v} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$\vec{v} = \frac{0}{t} = 0$$

127. A body is travelling east with a speed of 9 m/s and with an acceleration of 2 m/s^2 acting west on it. The displacement of the body during the 5th second of its motion is

(a) 0.25 m (b) 0.5 m
(c) 0.75 m (d) zero

J&K-CET-2015

Ans. (d) : Given,
u = 9 m/s east direction
a = 2m/s^2 west direction

Distance covered in tth second (retardation)-

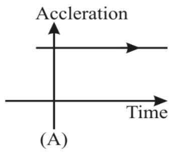
$$s_t = u - \frac{1}{2}a(2t-1) \qquad \{\because s_t = 5 \text{ sec}\}$$

$$s_5 = 9 - \frac{1}{2} \times 2\,(2 \times 5 - 1) = 9 - (10 - 1)$$

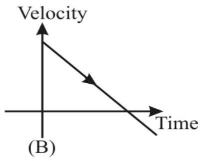
$$s_5 = 0$$

128. The graph which cannot possibly represent one-dimensional motion is

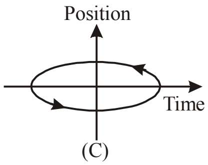
(a)



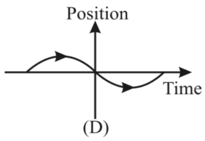
(b)



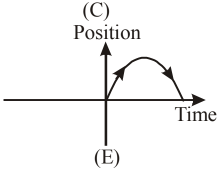
(c)



(d)



(e)



Kerala CEE - 2016

Ans. (c) : In one dimension motion, At t = 0, the body must at one position in graph. Hence option c has two positions in the graph at t = 0, it will be correct option.

129. For a particle moving according to the equation $x = a\cos\pi t$, the displacement in 3 s is

(a) 0 (b) 0.5a
(c) 1.5a (d) 2 a
(e) a

Kerala CEE - 2015

Ans. (d) : Given that,
At $t = 0$, $x = a\cos\pi(0)$
$x = a$
At $t = 3$,
$x = a\cos(3\pi)$
$x = -a$

Total displacement $(\Delta x) = a - (-a) = 2a$

130. The time required to stop a car of mass 800 kg, moving at a speed of 20 ms^{-1} over a distance of 25 m is

(a) 2 s (b) 2.5 s
(c) 4 s (d) 4.5 s
(e) 1 s

Kerala CEE - 2015

@apna_pdf

Ans. (b) : From the given question , we can acquire that,

$$u = 20 \text{ m/s}, \quad v = 0, \quad s = 25 \text{ m}$$

From the equation,

$v^2 - u^2 = 2as$

$(0)^2 - (20)^2 = 2 \times a \times 25$

$-400 = 50 \times a$

$a = -8 \text{ m/s}^2$

From the equation,

$$v = u + at$$
$$0 = 20 - 8t$$
$$20 = 8t$$
$$t = \frac{20}{8} = 2.5 \text{ second}$$

131. A bullet when fired into a target loses half of its velocity after penetrating 20 cm. Further distance of penetration before it comes to rest is

(a) 6.66 cm
(b) 3.33 cm
(c) 12.5 cm
(d) 10 cm
(e) 5 cm

Kerala CEE- 2014

Ans. (a) : Given that, initial velocity, u = v

Final velocity v = v/2

Distance (s) = 20 cm

Let the further distance of entry before coming to rest be x.

$$v^2 = u^2 - 2as$$
$$\left(\frac{v}{2}\right)^2 = v^2 - 2a \times 20$$
$$40\, a = \frac{3v^2}{4}$$
$$a = \frac{3v^2}{160} \qquad \text{....(i)}$$

Again,

$$v^2 = u^2 + 2as$$
$$v^2 = 0 + 2a \times (20 + x)$$

Putting value of a from equation (i)

$$v^2 = 2 \times \frac{3}{160} v^2 \times (20 + x)$$
$$1 = \frac{3}{80}(20 + x)$$
$$x = \frac{80 - 60}{3}$$
$$x = 6.66 \text{ cm}$$

132. Two cars started moving with initial velocities v and 2 v. For the same deceleration, their respective stopping distances are in the ratio

(a) 1 : 1
(b) 1 : 2
(c) 1 : 4
(d) 2 : 1
(e) 4 : 1

Kerala CEE 2012

Ans. (c) : Initial velocity u = v

Final velocity = 0

Deceleration = a

From the 3rd equation of motion

For first car:

$$v_1^2 = u^2 - 2as_1 \begin{bmatrix} v_1 = \text{final velocity} \\ u = \text{initial velocity} \end{bmatrix}$$
$$0 = v^2 - 2as_1$$
$$s_1 = \frac{v^2}{2a} \qquad \text{....(i)}$$

For second car:

Initial velocity = 2v

Final velocity = 0

Deceleration = a

$$v_2^2 = u^2 - 2as_2$$
$$0 = (2v)^2 - 2as_2$$
$$s_2 = \frac{2v^2}{a} \qquad \text{....(ii)}$$

Dividing both equation

$$\frac{s_1}{s_2} = \frac{v^2}{2a} \times \frac{a}{2v^2}$$
$$\frac{s_1}{s_2} = \frac{1}{4} \text{ or } 1 : 4$$

133. A body is falling freely under gravity. The distances covered by the body in first, second and third second of its motion are in the ratio

(a) 1 : 4 : 9
(b) 1 : 2 : 3
(c) 1 : 3 : 5
(d) 1 : 5 : 6
(e) 1 : 5 : 13

Kerala CEE – 2009, 2012

Ans. (c) Given that the body is freely falling under gravity initial velocity u = 0

From the equation of motion

$$s = ut + \frac{1}{2}at^2$$

Considering a = 10 m/s^2

For first second, we get

$$s_1 = 0 \times 1 + \frac{1}{2} \times 10 \times (1)^2$$

$s_1 = 5$m

For 2 second, we get

$$s_2 = 0 \times 1 + \frac{1}{2} \times 10 \times (2)^2$$

$s_2 = 20$m

So, distance travelled in 2nd second = 20 – 5 = 15 m

For 3 sec, we get

$$s_3 = 0 \times 1 + \frac{1}{2} \times 10 \times (3)^2$$

$s_3 = 45$m

So, the distance travelled in 3rd second = 45 – 20 = 25 m

$s_1 = 5$m, $s_2 = 15$m, $s_3 = 25$m

Therefore, the ratio is in the order of 1 : 3 : 5

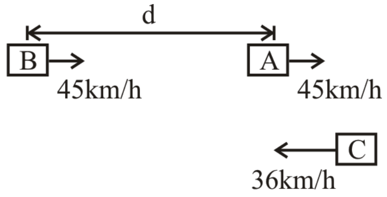
@apna_pdf

134. **Two cars A and B are moving with same speed of 45 km/h along same direction. If a third car C coming from the opposite direction with a speed of 36 km/h meets two cars in interval of 5 min, the distance of separation of two cars A and B should be (in km)**

(a) 6.75 (b) 7.25
(c) 5.55 (d) 8.35
(e) 4.75

Kerala CEE - 2008

Ans. (a) :



d will always remain constant car A & B have same velocity

Velocity of car w. r. to A & B,

$$V_{C/A} = V_{C/B} = 45 + 36 = 81 \text{ km/h} = 81\times\left(\frac{5}{18}\right)\text{m/s}$$

$$= \frac{45}{2}\text{m/s}$$

Distance between A and B = Velocity of approach × Time difference in meeting A and B

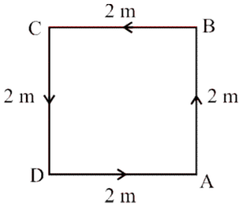
$$d = \frac{45\times5\times60}{2} = 6750\text{m} = 6.75 \text{ km}$$

135. **A toy cyclist completes one round of a square track of side 2m in 40s. What will be the displacement at the end of 3 min?**

(a) 52 m (b) zero
(c) 16 m (d) $2\sqrt{2}$m
(e) $4\sqrt{2}$m

Kerala CEE 2006

Ans. (d) :



In 3 min. the cyclist will make $= \frac{3\times60}{40} = 4.5$ round

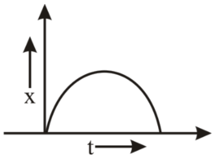
So, In four round, cyclist displacement equals to zero. But in half round cyclist will be diagonally opposite from where he started, so the displacement will be

$$AC^2 = AB^2 + BC^2$$

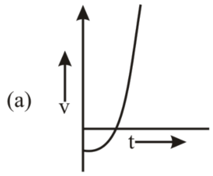
$$AC = \sqrt{2^2+2^2}$$

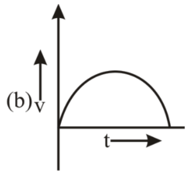
$$AC = 2\sqrt{2} \text{ m}$$

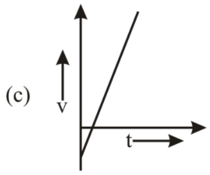
136. **The displacement – time (x–t) graph of a body is given as**

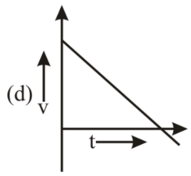


The corresponding velocity time (v-t)graph will be



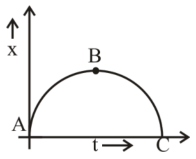






UPSEE - 2015

Ans. (d) :



$$v = \frac{dx}{dt}$$

∵ From A to B → $\frac{dx}{dt}$ is positive (v is positive)

At point B , $\frac{dx}{dt} = 0$

∴ $v = 0$

From B to C → $\frac{dx}{dt}$ is negative

∴ v is negative

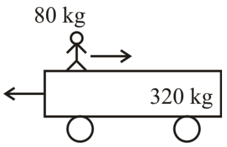
∴ Graph (d) satisfies all these condition.

137. **A man weighing 80 kg is standing on a trolley weighing 320 kg. The trolley is resting on frictionless horizontal rails. If the man starts walking on the trolley along the rails at speed 1 m/s. Then after 4 s, his displacement relative to ground will be**

(a) 4.5 m (b) 5 m
(c) 8 m (d) 3.2 m

UPSEE - 2012

Ans. (d) :



Displacement of man with respect to trolley = 4×1 = 4 m

∵ No external force → centre of mass is at rest

@apna_pdf

Let the distance moved by trolley be x in direction opposite to that of man.

So,

Net displacement of man is (4 – x) m.

$\therefore$ $320 \times x = 80(4 - x)$

$x = 0.8$ m

The relative displacement of man with respect to ground = 4 – x = 4 – 0.8 = 3.2 m

138. A body having constant speed can have varying velocity.

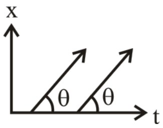
II. Position time graphs for two objects with zero relative velocity are parallel.

III. The numerical ratio of velocity to speed of an object can never be more than one

(a) (i)
(b) (i) and (ii)
(c) All
(d) None of these

UPSEE - 2009

Ans. (c) :



- A body having constant speed can have varying velocity as direction may change. e.g. uniform circular motion
- Position time graph for two objects with zero relative velocity are parallel. It means slope is same. Hence relative velocity is zero.
- For a given time internal,

  Distance ≥ [Displacement]

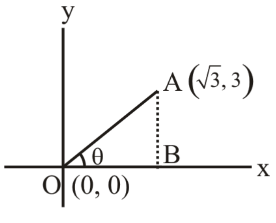
  Average speed ≥ [Average velocity]

139. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are $(\sqrt{3},3)$. The path of the particle makes with the x - axis an angle of

(a) 30°
(b) 45°
(c) 60
(d) 0°

UPSEE - 2007

Ans. (c) : Particle starts moving from (0, 0) and goes till $(\sqrt{3},3)$.



We know $\tan\theta = \frac{y}{x}$

$\therefore$ $\tan\theta = \frac{3}{\sqrt{3}}$ = slope of line OA

$\theta = \tan^{-1}(\sqrt{3})$

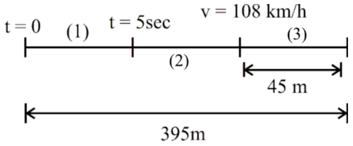
$\boxed{\theta = 60^\circ}$

140. A metro trains starts from rest and in five seconds achieves 108 km/h. After that it moves with constant velocity and comes to rest after travelling 45 m with uniform retardation. If total distance travelled is 395m, find total time of travelling.

(a) 12.2 s
(b) 15.3 s
(c) 9 s
(d) 17.2 s

UPSEE - 2006

Ans. (d) : Given that,



$v = 108$ km/h = 30m/s

Distance travelled in 1st 5 second,

$\therefore$ $v = u + at$

$30 = 0 + a \times 5$ $\{\therefore u = 0\}$

$a = 6$m/s

$v^2 = u^2 + 2as$

$(30)^2 = 0 + 2 \times 6 \times s$

$s_1 = 75$m

$t_1 = 5$ sec

For (2), distance travelled with uniform speed of 30 m/s is s_2 –

$s_1 + s_2 + s_3 = 395$

$s_2 = 395 - s_1 - s_3$

$= 395 - 45 - 75$

$s_2 = 275$m

$\therefore$ $t_2 = \frac{275}{30}$

$t_2 = 9.2$ sec

For (3),

$v^2 = u^2 + 2as$

$0 = (30)^2 - 2 \times a \times 45$

$a = 10\text{m/s}^2$

For uniform retardation (a = –a)

$v = u - at$

$t_3 = \frac{u}{a}$ $\{\therefore$ after rest, $v = 0\}$

$t_3 = \frac{30}{10} = 3\text{sec}$

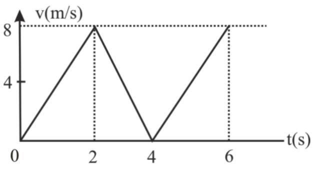
Total time taken in whole journey

$t = t_1 + t_2 + t_3$

$t = 5 + 9.2 + 3$

$t = 17.2\,\text{sec}$

141. The v-t graph for a particle is as shown. The distance travelled in the first four seconds is :



(a) 12 m
(b) 16 m
(c) 20 m
(d) 24 m

UPSEE - 2005

@apna_pdf

Ans. (b) : Distance travelled = Area under v-t graph

$\therefore$ Area of triangle $= \frac{1}{2} \times$ base $\times$ height

So, Distance travelled in 4 sec $= \frac{1}{2} \times 4 \times 8 = 16\text{m}$

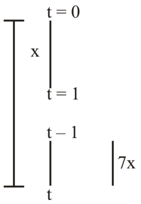
142. A body dropped from the top of a tower covers a distance 7x in the last second of its journey, where x is the distance covered in first second. How much time does it take to reach the ground?

(a) 3 s (b) 4 s

(c) 5 s (d) 6 s

JCECE-2011

Ans. (b) :



$$s_t - s_{t-1} = \left[ut + \frac{1}{2}gt^2\right] - \left[u(t-1) + \frac{1}{2}g(t-1)^2\right]$$

$$= ut + \frac{1}{2}gt^2 - \left[ut - u + \frac{1}{2}g\left[t^2 - 2t + 1\right]\right]$$

$$= u + gt - \frac{1}{2}g$$

$$s_{t^{th}} = g\left(t - \frac{1}{2}\right) \qquad \{\because u = 0\}$$

When, $t = 0$ to 1

Then,

$$x = g\left(1 - \frac{1}{2}\right) \Rightarrow x = \frac{g}{2} \qquad \text{....(i)}$$

When time $(t - 1)$ to (t)

Then,

$$7x = g\left(t - \frac{1}{2}\right) \Rightarrow 7x = gt - \frac{g}{2}$$

$$\frac{7g}{2} = gt - \frac{g}{2}$$

$$\Rightarrow \frac{7g}{2} + \frac{g}{2} = gt$$

$$\Rightarrow \frac{8g}{2} = gt$$

$t = 4$ sec.

143. At what angle must the two forces (x + y) and (x – y) act so that the resultant may be $\sqrt{(x^2 + y^2)}$?

(a) $\cos^{-1}\left[-\frac{(x^2 + y^2)}{2(x^2 - y^2)}\right]$

(b) $\cos^{-1}\left[\frac{-2(x^2 - y^2)}{x^2 + y^2}\right]$

(c) $\cos^{-1}\left[-\frac{(x^2 + y^2)}{(x^2 - y^2)}\right]$

(d) $\cos^{-1}\left[-\frac{(x^2 - y^2)}{(x^2 + y^2)}\right]$

JCECE-2010

Ans. (a) : Given,

$A = x + y, \qquad R = \sqrt{x^2 + y^2}$

$B = x - y$

So resultant force formula with angle θ,

$$R^2 = A^2 + B^2 + 2AB\cos\theta$$

$$x^2 + y^2 = (x + y)^2 + (x - y)^2 + 2(x + y)(x - y)\cos\theta$$

$$x^2 + y^2 = 2(x^2 + y^2) + 2(x + y)(x - y)\cos\theta$$

$\{\because (a + b)^2 + (a - b)^2 = 2(a^2 + b^2)\}$

$$-(x^2 + y^2) = 2(x^2 - y^2)\cos\theta$$

$$\cos\theta = \frac{-(x^2 + y^2)}{2(x^2 - y^2)}$$

So, $\theta = \cos^{-1}\left[\frac{-(x^2 + y^2)}{2(x^2 - y^2)}\right]$

144. A particle moves along Y-axis in such a way that its y-coordinate varies with time t according to the relation y = 3 + 5t + 7t². The initial velocity and acceleration of the particle are respectively:

(a) 14 ms^{-1}, –5 ms^{-2} (b) 19 ms^{-1}, –9 ms^{-2}

(c) –14 ms^{-1}, –5 ms^{-2} (d) 5 ms^{-1}, 14 ms^{-2}

JCECE-2005

Ans. (d) : Given that,

$y = 3 + 5t + 7t^2$

$$\therefore v = \frac{dy}{dt} = \frac{d}{dt}(3 + 5t + 7t^2)$$

$v = 5 + 14t$

Its initial velocity at $t = 0$

Then, $v = 5$ m/sec

$$\therefore \quad a = \frac{dv}{dt} = \frac{d}{dt}(5 + 14t)$$

$a = 0 + 14$

$a = 14$

So, acceleration (a) = 14 m/sec^2

The initial velocity and acceleration of particle are 5 m/s and 14 m/s^2 respectively

145. An aeroplane moves 400 m towards the north, 300 m towards west and then 1200 m vertically upwards, then its displacement from the initial position is

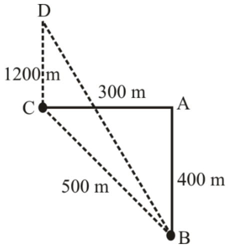
(a) 1600 m (b) 1800 m

(c) 1500 m (d) 1300 m

AIIMS-1998

@apna_pdf

Ans. (d) : Here, CD is perpendicular to the plane of paper. Required distance = BD



$$CB^2 = BA^2 + AC^2$$
$$CB^2 = 400^2 + 300^2$$
$$CB = \sqrt{400^2+300^2} = 500\,m$$
$$BD^2 = CB^2 + CD^2$$
$$BD^2 = 500^2 + 1200^2$$
$$BD = \sqrt{500^2+1200^2} = 1300\,m$$

146. For a body starting from rest, what will be the ratio of the distance travelled by the body during the 4th and 3rd second during its journey?

(a) $\frac{7}{5}$ (b) $\frac{7}{3}$

(c) $\frac{5}{7}$ (d) $\frac{3}{7}$

BCECE-2012
AIPMT-1993

Ans. (a) : We know that the distance travelled by a particle in nth second is given as

$$s_n = u + \frac{a}{2}(2n-1)$$

Thus, the ratio of distance travelled in 4th to 3rd second

is $$\frac{s_{4^{th}}}{s_{3^{rd}}} = \frac{0+\frac{a}{2}(2\times4-1)}{0+\frac{a}{2}(2\times3-1)} = \frac{2\times4-1}{2\times3-1} = \frac{7}{5}$$

147. An object accelerates from rest to a velocity 27. 5 m/s in 10s, then the distance covered after next 10s is :

(a) 550 m (b) 137.5 m

(c) 412.5 m (d) 175 m

BCECE-2004

Ans. (c) : Given,

$$u = 0,\ v = 27.5\ m/s,\ t = 10\ sec,\ a = ?$$

From v = u + at

$$\therefore \quad a = \frac{v-u}{t} = \frac{27.5-0}{10}$$
$$= \frac{27.5}{10} = 2.75\ m/s$$

In the first 10sec, distance travelled

From $S = ut + \frac{1}{2}at^2$

$$S_1 = 0\times10 + \frac{1}{2}\times2.75\times(10)^2 = 137.5m$$

In the first 20sec, distance travelled

$$S_2 = 0\times20 + \frac{1}{2}\times2.75\times(20)^2 = 550\ m$$

Hence, distance travelled in next 10s.

= 550 – 137.5 = 412.5 m

148. A body of mass m thrown horizontally with velocity v, from the top of tower of height h, touches the level of ground at a distance of 250 m from the foot of the tower. A body of mass 2 m, thrown horizontally with velocity v/2, from the top of a tower of height 4 h will touch the level ground at a distance in metre from the foot of the tower is

(a) 150 m (b) 200 m

(c) 250 m (d) 2500 m

EAMCET-1991

Ans. (c) : Given data,

Distance from the foot of the tower, = 250m

As we know,

$$t = \sqrt{\frac{2h}{g}}$$

$$\therefore \text{ Distance, } d = vt = v\sqrt{\frac{2h}{g}} = 250m$$

According to given question,

$$\text{When, } v = \frac{v}{2}, \quad h = 4h$$

$$\text{Then, distance, } x = \frac{v}{2}\sqrt{\frac{2(4h)}{g}} = v\sqrt{\frac{2h}{g}}$$

$$\therefore \qquad x = 250m$$

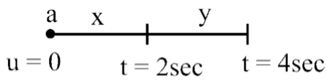
149. A particle starts moving from rest under uniform acceleration. It travels a distance x in the first two seconds and a distance of y in the next two seconds. If y = n x, then n =

(a) 1 (b) 3

(c) 2 (d) 4

EAMCET-1993

Ans. (b) : Given that,



According to question,

Distance covered in 2 sec, $x = \frac{1}{2}.at^2 = \frac{1}{2}.a\times(2)^2 = 2a$

Similarly,

Distance covered in next 4 sec, $y = \frac{1}{2}.a(4)^2 - \frac{1}{2}a(2)^2$

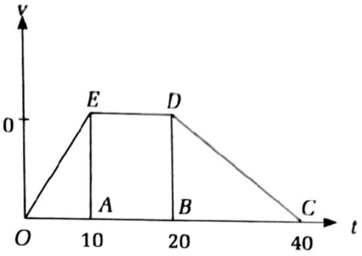
$$y = 6a$$

From question

$$y = nx$$
$$6a = n\times2a$$
$$n = 3$$

@apna_pdf

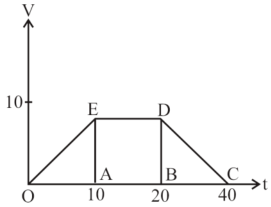
150. In the following velocity-time graph, the distance travelled by the body, in metre is



(a) 200 (b) 250
(c) 300 (d) 400

EAMCET-1994

Ans. (b) : From given figure,



Distance travelled by the body is

S = Area of ΔOAE + Area of □ EDAB + Area of ΔDBC

$= \frac{1}{2}\times10\times10+10\times10+\frac{1}{2}\times10\times20$

= 50 + 100 + 100 = 250m

151. A body A starts from rest with an acceleration a_1. After 2 s another body B starts from rest with an acceleration a_2. If they travel equal distance in the 5th second after the start of A. $a_1 : a_2$ is equal to

(a) 5 : 9 (b) 5 : 7
(c) 9 : 5 (d) 9 : 7

EAMCET-1994

Ans. (a) : As per given condition,

Distance travelled in 5^{th} second = distance travelled in 3^{rd} second.

$$u+\frac{a_1}{2}(2n-1) = u+\frac{a_2}{2}(2n-1)$$

Or, $\frac{a_1}{2}(2\times5-1)=\frac{a_2}{2}(2\times3-1)$ $[\because u=0]$

Or, $\frac{9}{2}a_1=\frac{5}{2}.a_2$

Or, $\frac{a_1}{a_2}=\frac{5}{9}$

∴ $a_1 : a_2 = 5 : 9$

152. A body falling for 2 s covers a distance s which is equal to that covered in next 1 s. If g=10 ms^{-2}, the distance s is

(a) 30 m (b) 10 m
(c) 60 m (d) 20 m

EAMCET-1995

Ans. (a) : As per given condition,

If u = initial velocity,

Distance covered in 2 sec = distance covered in 3^{rd} sec

$$S = ut + \frac{1}{2}gt^2 = u + \frac{g}{2}(2n-1)$$

$$u\times 2 + \frac{1}{2}\times10\times2^2 = u + \frac{10}{2}(2\times3-1)$$

$$2u + 20 = u + 25$$

$$u = 5m/s$$

Distance, $s = ut + \frac{1}{2}gt^2$

$$s = 5\times 2 + \frac{1}{2}\times10\times2^2$$

$$s = 10 + 20$$

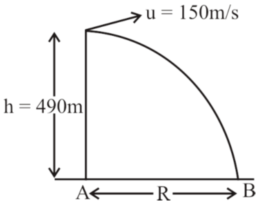
$$s = 30m$$

153. A bomb is dropped from an aircraft travelling horizontally at 150 ms^{-1} at a height of 490 m. The horizontal distance travelled by the bomb before it hits the ground is (in metre)

(a) 1000 (b) 1200
(c) 1500 (d) 1800

EAMCET-1996

Ans. (c) :



$R = u.t \Rightarrow R = u.\sqrt{\frac{2h}{g}}$ $\left\{\begin{array}{l}\because h = ut+\frac{1}{2}gt^2\\ h=\frac{1}{2}gt^2,\ \ u=0\\ t=\sqrt{\frac{2h}{g}}\end{array}\right\}$

$$R = 150\times\sqrt{\frac{2\times490}{9.8}}$$

$$R = 150\times\sqrt{100}$$

$$R = 1500m$$

154. The reaction time for a car diver is 0.9 s. If the car travelling initially with 36 km h^{-1} is stopped by the driver after observing a signal by the deceleration of 5 ms^{-2}, the total distance travelled by the car before coming to rest is

(a) 19 m (b) 9 m
(c) 10 m (d) 28 m

EAMCET-1997

Ans. (a) : Given data,

$$u = 36\text{ km/h} = 36\times\frac{5}{18}=10m/s$$

$$t = 0.9sec$$

$$s_1 = ut = 10\times0.9 = 9m \Rightarrow s_1 = 9m$$

@apna_pdf

For deceleration, $v = u + gt$

$$0 = 10 - 5t_1$$

$$t_1 = 2 \text{ sec}$$

∴ Distance travelled after deceleration,

$$s_2 = ut_1 - \frac{1}{2}at_1^2$$

Or, $s_2 = 10 \times 2 - \frac{1}{2} \times 5 \times 2^2$

Or, $s_2 = 20 - 10$

∴ $s_2 = 10\text{m}$

So, total distance travelled by the car, $s = s_1 + s_2$

$$s = 9 + 10 = 19$$

$$s = 19\text{m}$$

155. A wheel of circumference C is at rest on the ground. When the wheel rolls forward through half a revolution, then the displacement of initial point of contact will be

(a) $C\sqrt{\frac{1}{\pi^2} + \frac{1}{4}}$ (b) $\frac{C}{2}$

(c) $\pi\sqrt{C^2 + 4}$ (d) $C\sqrt{\frac{1}{\pi} + \frac{1}{2}}$

AP EAMCET(Medical)-2016

Ans. (a) : Let horizontal distance = x

and vertical distance = y

Circumference of wheel = C

∴ $x = \frac{C}{2}$ and $Y = \frac{C}{\pi}$

∴ Total displacement, $d = \sqrt{x^2 + y^2}$

$$d = \sqrt{\left(\frac{C}{2}\right)^2 + \left(\frac{C}{\pi}\right)^2}$$

∴ $$d = C\sqrt{\frac{1}{4} + \frac{1}{\pi^2}} = C\sqrt{\frac{1}{\pi^2} + \frac{1}{4}}$$

156. The distances travelled by a body starting from rest and travelling with uniform acceleration, in successive intervals of time of equal duration will be in the ratio:

(a) 1:2:3 (b) 1:2:4

(c) 1:3:5 (d) 1:5:9

AP EAMCET(Medical)-1999

Ans. (c) :

Distance travelled in first time interval, $D_1 = \frac{1}{2}.a(\Delta t)^2$

And distance travelled in 2nd time interval,

$$D_2 = \frac{1}{2}.a.(2\Delta t)^2 - \frac{1}{2}.a.(\Delta t)^2$$

$$D_2 = \frac{3}{2}.a\Delta t^2$$

Similarly, distance travelled in 3rd time interval,

$$D_3 = \frac{1}{2}.a(3\Delta t)^2 - \frac{1}{2}.a(2\Delta t)^2$$

$$D_3 = \frac{5}{2}.a\Delta t^2$$

So, $D_1 : D_2 : D_3 = 1 : 3 : 5$

157. A stone is thrown vertically upwards with a velocity 30 ms^{-1}. If the acceleration due to gravity is 10 ms^{-2}, what is the distance travelled by the particle during the first second of its motion?

(a) 10 m (b) 25 m

(c) 30m (d) None of the above

SRM JEE - 2009

Ans. (b) : Given: Initial velocity, u = 30 m/s

Distance travelled during the first second of motion will be

$$s = ut + \frac{1}{2}at^2$$

$$s = 30 \times 1 - \frac{1}{2}g(1)^2 \qquad [\because a = -g]$$

$$s = 30 \times 1 - \frac{1}{2} \times 10$$

$$s = 25 \text{ m}$$

158. What will be the ratio of the distance moved by a freely falling body from rest in 4th and 5th second of journey?

(a) 4: 5 (b) 7: 9

(c) 16: 25 (d) 1: 1

[AIPMT 1989]

Ans. (b): Distance moved by a freely falling body from rest in 4 second is given by

$$s_n = \frac{1}{2}gt^2$$

$$s_4 = \frac{1}{2}g(4)^2 = \frac{1}{2}g \times 16$$

Similarly $s_5 = \frac{1}{2}g(5)^2 = \frac{1}{2}g \times 25$

$$s_3 = \frac{1}{2}g(3)^2 = \frac{1}{2}g \times 9$$

Distance moved in 5th second = (distance moved in 5 second)–(distance moved in 4 second)

$$= s_5 - s_4 = \frac{1}{2}g \times 25 - \frac{1}{2}g \times 16$$

$$= \frac{1}{2}g(25 - 16)$$

Distance moved in 4th second –

$$s_4 – s_3 = \frac{1}{2}g \times 16 - \frac{1}{2}g \times 9$$

$$= \frac{1}{2}g(16 - 9)$$

Ratio of distance moved in 4th and 5th second

$$= \frac{\frac{1}{2}g(16-9)}{\frac{1}{2}g(25-16)} = \frac{16-9}{25-16} = \frac{7}{9}$$

159. If a car at rest, accelerates uniformly to a speed of 144km/h in 20s, it covers a distance of

(a) 2880 m (b) 1140 m

(c) 400 m (d) 20 m

[AIPMT 1997]

@apna_pdf

Ans. (c): Car at rest u = 0

Time t = 20 sec.

Speed after 20 second, v = 144 km/h

$$v = 144 \times \frac{5}{18} \text{ m/s}$$

v = 40 m/s

Let, acceleration = a m/s^2

$$v = u + at$$
$$40 = 0 + a \times 20$$
$$a = 2 \text{ m/s}^2$$

Distance cover in 20 second is given by

$$v^2 = u^2 + 2as$$
$$(40)^2 = 0 + 2 \times 2 \times s$$
$$1600 = 4\ s$$
$$s = 400 \text{ m}$$

160. A train is moving towards east and a car is along north, both with same speed. The observed direction of car to the passenger in the train is

(a) East-north direction
(b) West-north direction
(c) South-east direction
(d) None of the above

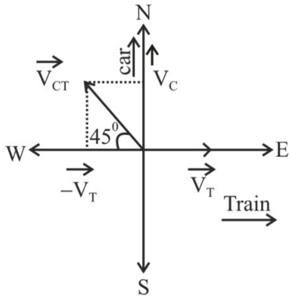
JIPMER-2011

Ans. (b): Speed of train = Speed of car

$V_T = V_C$

Train is moving towards east direction if V_T is speed of train then velocity vector $\overrightarrow{V_T}$

Velocity vector of car = $\overrightarrow{V_C}$



The observed direction of car to the passenger in the train is $\overrightarrow{V_{CT}}$.

$$\overrightarrow{V_{CT}} = \overrightarrow{V_C} - \overrightarrow{V_T}$$

From figure the direction of $\overrightarrow{V_{CT}}$ is west north direction.

161. The area of the acceleration-displacement curve of a body gives

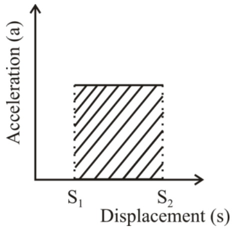
(a) Impulse
(b) Change in momentum per unit mass
(c) Change in KE per unit mass
(d) Total change in energy

JIPMER-2008

Ans. (c): Acceleration = a

Displacement = s

Area under curve = as



If u is initial velocity v, is final velocity and s is displacement.

Then,

$$v^2 = u^2 + 2as$$

$$\frac{1}{2}\left(v^2 - u^2\right) = as \quad ....(i)$$

We know that, change in Kinetic energy (KE)

$$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{K.E.} = \frac{1}{2}m(v^2 - u^2)$$

Change in Kinetic energy per unit mass = $\frac{\text{K.E}}{m}$

$$= \frac{\frac{1}{2}m(v^2 - u^2)}{m}$$

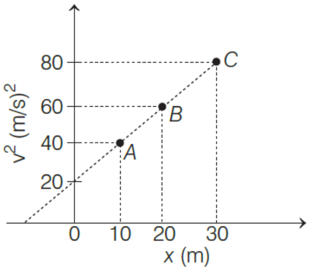
Change in K.E per unit mass = $\frac{1}{2}\left(v^2 - u^2\right)$ ....(ii)

From equation (i) and (ii)

Area under curve = change in K.E. per unit mass

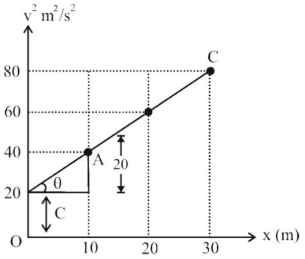
$$as = \frac{1}{2}(v^2 - u^2)$$

162. A particle is moving with constant acceleration a. Following graph shows v^2 versus x (displacement) plot. The acceleration of the particle is .... m/s^2



JEE MAIN 31.08.2021, Shift-II

Ans. (1) :



@apna_pdf

In the above graph slope (m) = $\tan\theta = \frac{20}{10} = 2$

Here figure shows straight line graph between v^2 versus x (displacement)

So, the equation of straight line is given by –

$$y = mx + c$$

$$\therefore \quad v^2 = 2x + 20 \quad \text{... (i)}$$

Differentiating the equation (i) we get–

$$\frac{d}{dx}\left(v^2\right) = 2\frac{d}{dx}(x) + \frac{d}{dx}(20)$$

$$2v\frac{dv}{dx} = 2 \times 1 + 0$$

$$v\frac{dv}{dx} = 1 \quad \text{...(ii)}$$

$$a = \frac{dv}{dx} = \text{(Rate of change of velocity)}$$

$$a = \frac{dv}{dt} \times \frac{dx}{dx}$$

$$a = \frac{dv}{dx} \times \frac{dx}{dt}$$

$$a = \frac{dv}{dx} \times v \qquad \because \left(v = \frac{dx}{dt}\right)$$

$$a = v\frac{dv}{dx} \quad \text{...(iii)}$$

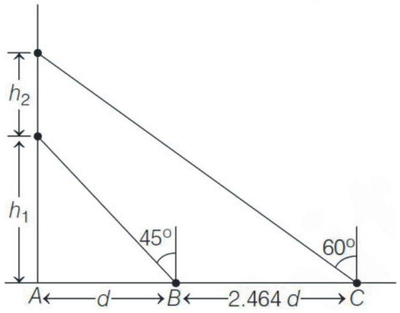
From equation (ii) and equation (iii) we get

$$a = v\frac{dv}{dx} = 1\,m/s^2$$

Hence, acceleration is 1 m/s^2.

163. A balloon is moving up in air vertically above a point A on the ground(d). When it is at a height h_1, a girl standing at a distance d (point B) from A (see figure) sees it at an angle 45° with respect to the vertical. When the balloon climbs up a further height h_2, it is seen at an angle 60° with respect to the vertical if the girl moves further by a distance 2.464 d (point C). Then, the height h_2 is

(Given, tan30°=0.5774)

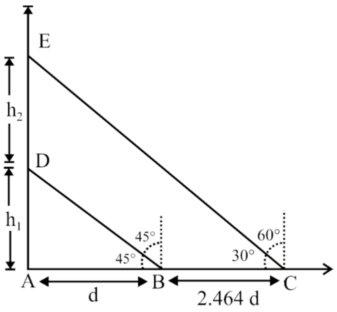


(a) 1.464 d (b) d

(c) 0.464 d (d) 0.732 d

JEE MAIN 05.09.2020, Shift-I

Ans. (b) :



In triangle ΔABD –

$$\tan 45° = \frac{\text{Perpendicular length}}{\text{Base}} = \frac{h_1}{d}$$

$$\because \quad \tan 45° = 1$$

$$1 = \frac{h_1}{d} \text{ Or } h_1 = d$$

Again in ΔACE –

$$\tan 30° = \frac{h_1 + h_2}{d + 2.464d}$$

$$\tan 30° = \frac{h_1 + h_2}{d + 2.464d} \qquad \because h_1 = d$$

$$\therefore \quad \tan30° = 0.5774$$

$$0.5774 \times 3.464d = d + h_2$$

$$2d - d = h_2$$

$$h_2 = d$$

164. A block is kept on the floor of an elevator at rest. The elevator starts descending with an acceleration of 12 m/s^2. Find the displacement of the block during the first 0.2 s after the start. (Take, g = 10 m/s^2)

(a) 30 cm (b) Zero

(c) 20 cm (d) 25 cm

JIPMER-2015

Ans. (c) : Given,

$t = 0.2$ sec

$g = 10\ m/sec^2$

$u = 0$

Given, elevator is descending with an acceleration of 12 m/s^2 (>g).

Hence, block will lose contact and freely fall.

$$s = ut + \frac{1}{2}gt^2$$

$$s = 0 \times 0.2 + \frac{1}{2} \times 10(0.2)^2$$

$$s = \frac{1}{2} \times 10 \times \frac{2}{10} \times \frac{2}{10}$$

$$s = 0.2\ m$$

$$s = 20\ cm$$

165. The distance x (in μm) covered by a molecule starting from point A at time t = 0 and stopping at another point B is given by the equation

$$\mathbf{x = t^2\left(2 - \frac{t}{3}\right)}$$

@apna_pdf

The distance between A and B (in μm) is closed to

(a) 10.7 (b) 20.7
(c) 40.7 (d) 50.7

JIPMER-2015

Ans. (a) : Given,

$$x = t^2\left(2-\frac{t}{3}\right)$$

$$x = 2t^2-\frac{t^3}{3} \qquad .....(i)$$

Differentiate equation (i) w.r.t. t both side,

$$\frac{dx}{dt} = 4t-\frac{3t^2}{3}$$

$$\frac{dx}{dt} = 4t-t^2$$

At point B, v = 0

$$4t - t^2 = 0$$

$$t = 4 \text{ sec}$$

The distance between A to B at t = 4 sec,

$$x = t^2\left(2-\frac{t}{3}\right)$$

$$x = (4)^2\left(2-\frac{4}{3}\right)$$

$$x = 16\times\frac{2}{3} = \frac{32}{3} = 10.66 = 10.7$$

166. An athlete completes one round of a circular track of radius R in 40 s. What will be his displacement at the end of 2 min 20 s ?

(a) 7R (b) 2R
(c) 2πR (d) 7πR

AP EAMCET -2010

Ans. (b) : t = 2 min 20 sec
= 140 sec

1 round of a circular track of radius R in 40 sec
3 round of a circular track of radius R in 120 s.
Then displacement zero.
t = 120 sec
Δt = 140 – 120 = 20 sec
Displacement = Diameter of circular track
= 2 × R
= 2R

167. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward and so on. Each step is 1 m long and requires 1 s. Determine how long the drunkard takes to fall in a pit 13 m away from the starting point.

(a) 37 s (b) 13 s
(c) 49 s (d) 18 s

AMU-2016

Ans. (a) : Distance covered in 1 step = 1m
Time taken = 1 sec
Time taken to move first 5 m forward = 5 s
Time taken to move 3 m backwards = 3 sec
Net distance covered = 5 – 3 = 2m
Net time taken to cover 2 m = 8 sec
Therefore,
Drunkard covers 2 m in 8 s , 4 m in 16 sec, 6 m in 24 sec and 8 m in 32 sec
That is, the drunkard will cover a distance of 5m in the next 5 sec.
A total distance of 13 m is covered and he falls into the pit.
Therefore,
Net time taken by the drunkard to cover 13m = 32 + 5 = 37 sec

168. By what velocity a ball be projected vertically upwards so that the distance covered in 5^{th} second is twice of that covered in 6^{th} second?

(a) 19.6 m/s (b) 58.8 m/s
(c) 49 m/s (d) 65 m/s

AMU-2013

Ans. (d) : We know,

$$s_n = u + \frac{1}{2}g(2n-1)$$

and $s_5 = 2 \times s_6$

$$u + \left(-\frac{10}{2}\right)(2\times5-1) = 2\left[u+\left(-\frac{10}{2}\right)(2\times6-1)\right]$$

$$u - 45 = 2u - 110$$

$$u = 65 \text{m/s}$$

169. A body of mass 0.4 kg starting at origin at t = 0 with a speed of 10 m/s in the positive x-axis direction is subjected to a constant force F = 8 N towards negative x-axis. Calculate the position of the particle after 25 second.

(a) –6000 m (b) –8000 m
(c) +4000 m (d) +7000 m

AMU-2012

Ans. (a) : Given,
Mass of the particle (m) = 0.4 kg
Force (F) = –8N

$$\text{Acceleration } (a) = \frac{F}{m} = \frac{-8N}{0.4kg} = -20 m/sec^2$$

Then, position of the body

$$s = ut + \frac{1}{2}at^2$$

$$s = 10\times25+\frac{1}{2}(-20)\times(25)^2$$

$$s = 250-6250$$

$$s = -6000 m$$

170. The displacement of a particle starting from rest (at t = 0) is given by the relation $s = 6t^2 - t^3$ The time in seconds when the velocity of the particle would again be zero is

(a) 3 seconds (b) 4 seconds
(c) 6 seconds (d) 10 seconds

AMU-2003

@apna_pdf

Ans. (b) : Given,
Displacement of the particles (s) = $6t^2 - t^3$
We know,

$$v = \frac{ds}{dt}$$

$$v = \frac{d\left(6t^2 - t^3\right)}{dt}$$

$$0 = 12\,t - 3t^2$$

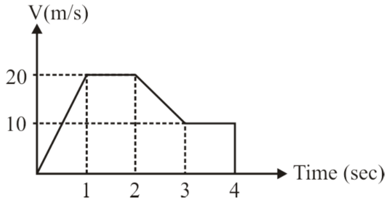
$$0 = 12t - 3t^2$$

$$3t^2 = 12t$$

$$t = 4$$

The time is 4 sec when the velocity of the particle would again be zero.

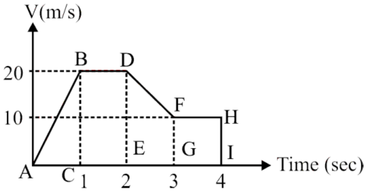
171. From the adjoining graph, the distance travelled by the particle in 4 sec is



(a) 60 m (b) 25 m
(c) 55 m (d) 30 m

AMU-2011

Ans. (c) :



From figure, Area of Δ (ABC) = $\frac{1}{2} \times 1 \times 20$

$= 10$ m

Area of rectangle (BCED) = 1×20

$= 20$ m

Area of trapezium (DFGE) = $\frac{1}{2} \times 1 \times (20 + 10)$

$= 15$ m

Area of rectangle (FHIG) = $1 \times 10 = 10$ m
Total Area = 10 + 20 + 15 + 10 = 55 m

172. A train moves from rest with acceleration α and in time t_1 covers a distance x. It then decelerates to rest at constant retardation β for distance y in time t_2. Then,

(a) $\frac{x}{y} = \frac{\beta}{\alpha}$ (b) $\frac{\beta}{\alpha} = \frac{t_1}{t_2}$

(c) $x = y$ (d) $\frac{x}{y} = \frac{\beta t_1}{\alpha t_2}$

WB JEE 2016

Ans. (a &b) : Option A and B both are correct.

From equation of motion, $s = ut + \frac{1}{2}at^2$

$$x = \frac{1}{2}\alpha t_1^2 \quad \text{.......(i)}$$

We know that the velocity is the derivative of the distance with respect to time.
Therefore,

$$\frac{dx}{dt} = \frac{d}{dt}\left(\frac{1}{2}\alpha t_1^2\right)$$

Let the velocity acquired here is v_1.

$$v_1 = \alpha t_1 \quad \text{... (ii)}$$

From the equation of motion,

$$v^2 - u^2 = 2as$$

$$0^2 - v_1^2 = -2\,\beta y$$

Put v_1 in eq^n (ii), we get –

$$(\alpha t_1)^2 = 2\beta y$$

$$y = \frac{(\alpha t_1)^2}{2\beta} \quad \text{... (iii)}$$

From (i) and (iii), we get –

$$\frac{x}{y} = \frac{\frac{1}{2}\alpha t_1^2}{\frac{(\alpha t_1)^2}{2\beta}}$$

$$\frac{x}{y} = \frac{\beta}{\alpha} \quad \text{...(iv)}$$

Also, we know that v = u + at
Here,
Final velocity = 0
Initial velocity = v_1
Acceleration = – β
Time = t_2
So,

$$0 = v_1 + (-\beta)\, t_2$$

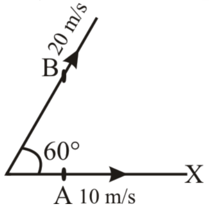
$$v_1 = \beta t_2$$

Substituting the value of v_1 from eq. (ii) in this equation, we get –

$$\alpha t_1 = \beta t_2$$

$$\frac{\beta}{\alpha} = \frac{t_1}{t_2}$$

173. Particle A moves along X-axis with a uniform velocity of magnitude 10 m/s. Particle B moves with uniform velocity 20 m/s along a direction making an angle of 60° with the positive direction of X-axis as shown in the figure. The relative velocity of B with respect to that of A is



@apna_pdf

(a) 10 m/s along X-axis
(b) $10\sqrt{3}$ m/s along Y-axis (perpendicular to X-axis)
(c) $10\sqrt{5}$ m/s along the bisection of the velocities of A and B
(d) 30 m/s along negative X-axis

WB JEE 2015

Ans. (b) : Particle A is moving along the x- axis.

Hence, it has only $\hat{i}$ component of direction.

Given that, $\vec{v}_A = 10\hat{i}$

Particle B has both X and Y components.

$$\vec{v}_B = 20\cos 60\hat{i} + 20\sin 60\hat{j}$$

$$= 20\left(\frac{1}{2}\right)\hat{i} + 20\left(\frac{\sqrt{3}}{2}\right)\hat{j} = 10\hat{i} + 10\sqrt{3}\hat{j}$$

The velocity of B with respect to A =

$$\vec{v}_{AB} = \vec{v}_B - \vec{v}_A = 10\hat{i} + 10\sqrt{3}\hat{j} - 10\hat{i}$$

$$\vec{v}_{AB} = 10\sqrt{3}\hat{j}$$

174. A particle moves along x-axis and its displacement at any time is given by $x(t) = 2t^3 - 3t^2 + 4t$ in SI units. The velocity of the particle when its acceleration is zero, is

(a) 2.5 ms^{-1}
(b) 3.5 ms^{-1}
(c) 4.54 ms^{-1}
(d) 8.5 ms^{-1}

WB JEE 2013

Ans. (a) : Given that,

Displacement at any time t-

$$x(t) = 2t^3 - 3t^2 + 4t$$

Differentiating w.r.t. t we get

$$v = \frac{dx}{dt} = 6t^2 - 6t + 4$$

Again differentiating w.r.t. t-

$$a = \frac{dv}{dt} = 12t - 6$$

Now $\frac{dv}{dt} = 0$

$$12t - 6 = 0$$

$$t = \frac{1}{2}$$

$$\text{at } t = \frac{1}{2} \text{ the velocity}(v) = 6\times\left(\frac{1}{2}\right)^2 - 6\times\frac{1}{2} + 4$$

$$= \frac{6}{4} - 3 + 4$$

$$v = 2.5 \text{ m/s}$$

175. A shell of mass 5M, acted upon by no external force and initially at rest, bursts into three fragments of masses M, 2M and 2M respectively. The first two fragments move in opposite directions with velocities of magnitudes 2v and v respectively. The third fragment will

(a) move with a velocity v in a direction perpendicular to the other two
(b) move with a velocity 2v in the direction of velocity of the first fragment
(c) be at rest
(d) move with velocity v in the direction of velocity of the second fragment

WB JEE 2013

Ans. (c) : Let the velocity of third fragment is v'.

Then according to law of conservation of momentum,

P = Constant

So, $5M \times 0 = M \times 2v - 2M \times v + 2M \times v'$

$0 = 2Mv - 2Mv + 2M \times v'$

or $2M \times v' = 0$

$v' = 0$

Hence, the third fragment will be at the rest.

176. The velocity of a car travelling on a straight road is 36 kmh^{-1} at an instant of time. Now travelling with uniform acceleration for 10 s, the velocity becomes exactly double. If the wheel radius of the car is 25 cm, then which of the following is the closest to the number of revolutions that the wheel makes during this 10 s?

(a) 84
(b) 95
(c) 126
(d) 135

WB JEE 2013

Ans. (b) :

Given that, radius of wheel (r) = 25 cm = 0.25m

Initial velocity of car (u) = 36 km/hr

$$= 36 \times \frac{5}{18} = 10 \text{ m/s}$$

Final velocity (v) = 2u = 2 × 10

= 20 m/ s

And, t = 10 second

$v = u + at$

$20 = 10 + a \times 10$

$a = 1 \text{ m/ s}^2$

Now $v^2 = u^2 + 2as$

$$s = \frac{v^2 - u^2}{2a}$$

$$s = \frac{(v-u)(v+u)}{2a} = \frac{10\times 30}{2\times 1} = 150\text{m}$$

$$\text{So, number of revolution} = \frac{s}{2\pi r} = \frac{150\times 100}{2\times 3.14\times 25}$$

$$\approx 95$$

177. If a person can throw a stone to maximum height of h meter vertically, then the maximum distance through which it can be thrown horizontally by the same person is

(a) $\frac{h}{2}$
(b) h
(c) 2h
(d) 3h

WB JEE 2011

Ans. (c) : Let a person throw a stone vertically with initial velocity u. The maximum height attained by the stone h so, at this height final velocity (v) is zero.

$v^2 - u^2 = 2(-g)h$

@apna_pdf

$0 - u^2 = -2gh$

$h = \frac{u^2}{2g}$ ……(i)

We know that, we get –

Maximum horizontal range, $R_{max} = \frac{u^2}{g}$ ….(ii)

$R_{max} = 2h$

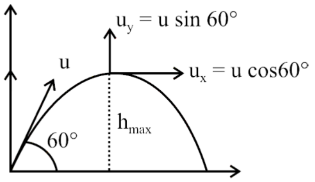
178. A bullet is fired with a velocity u making an angle of 60° with horizontal plane. The horizontal component of the velocity of the bullet when it reaches the maximum height is

(a) u (b) 0

(c) $\frac{\sqrt{3}u}{2}$ (d) u/2

WB JEE 2009

Ans. (d) :



We know that the horizontal velocity remains the same in case if the projectile motion. So, in the given case the horizontal velocity will be the horizontal component of the velocity of the Bullet.

Now, the horizontal component = $u \cos 60° = \frac{u}{2}$

This velocity will remain same throughout the projectile motion whether it is at the maximum height or whether it is in minimum height.

179. A bullet emerges from a barrel of length 1.2 m with a speed of 640 ms^{-1}. Assuming constant acceleration, the approximate time that it spends in the barrel after the gun is fired is

(a) 4 ms (b) 40 ms

(c) 400 μs (d) 1 s

WB JEE 2008

Ans. (a) : Given that,

s = 1.2 m v = 640 m/sec, u = 0

We know that,

$v^2 = u^2 + 2as$

$v^2 = (0)^2 + 2 \times a \times 1.2$

$(640)^2 = 2 \times a \times 1.2$

$a = \frac{(640)^2}{2.4}$ m/sec^2

$\because$ v = u + at

$t = \frac{v}{a}$ ($\because$ u = 0)

$t = \frac{640}{\frac{(640)^2}{2.4}} = \frac{2.4}{640} \approx 0.004$ sec ≈ 4ms

180. A shell of mass 10 kg is moving with a velocity of 10 ms^{-1} when it blasts and forms two parts of mass 9 kg and 1 kg respectively. If the 1st mass is stationary, the velocity of the 2nd is

(a) 1 m/s (b) 10 m/s

(c) 100 m/s (d) 1000 m/s

WB JEE 2008

Ans. (c) : Given that,

$m_1 = 10$ kg, $v_1 = 10$m/sec

$m_2 = 9$ kg, $v_2 = 0$

$m_3 = 1$kg $v_3 = v$

According to the law of conservation of momentum

$m_1v_1 = m_2v_2 + m_3v_3$

$10 \times 10 = 9 \times 0 + 1 \times v$

100 = v

v = 100 m/sec

181. The distance travelled by an object along a straight line in time t is given by $s = 3 - 4t + 5t^2$, the initial velocity of the object is

(a) 3 unit (b) –3 unit

(c) 4 unit (d) –4 unit

WB JEE 2008

Ans. (d) : Distance travelled by an object is-

$s = 3 - 4t + 5t^2$

Differentiate w.r.t 't' both side, we get –

$\frac{ds}{dt} = 0 - 4 + 10t$

Initial velocity (t = 0)

$u = 0 - 4 + 10 \times 0$ $\left[\because \frac{ds}{dt} = u\right]$

u = –4 unit

182. If the displacement of a particle changes with time as $\sqrt{x} = t + 3$, then the velocity of the particle will be proportional to

(a) t^{-1} (b) t

(c) $\sqrt{t}$ (d) t^2

WB JEE-2007

Ans. (b) : Given that,

Displacement of the particles $x = (t + 3)^2$

$\because$ $v = \frac{dx}{dt}$

$\therefore$ $\frac{d(t+3)^2}{dt} = 2(t + 3)$

$v = 2t + 6$

$v \propto t$

So, the velocity of the particle will be proportional to t

183. Fig (1) and (2) show the displacement time graphs of two particles moving along the x-axis. we can say that.

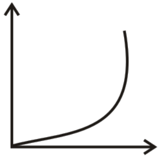


fig.(1)

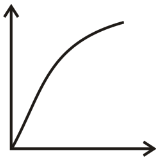


fig. (2)

@apna_pdf

(a) Both the particles are having a uniform accelerated motion
(b) Both the particle are having a uniform retarted motion
(c) Particle (1) is having uniform accelerated motion while particle (2) is having a uniform retarted motion
(d) Particle (1) is having a uniformly retarted motion while particle (2) is having a uniformly accelerated motion

UP CPMT-2009

Ans. (c) : From the equation of second law of motion for uniform acceleration $x = x_0 + \frac{1}{2}at^2$

The slope of displacement – time graph gives increasing velocity in figure (i). The speed of particle keeps on increasing with time.

Thus the velocity of particle increases with time and the particle has accelerated motion .

The slope of displacement -time graph gives decreasing velocity with time so the particle has retarded motion for uniformly accelerated or retarded motion, the displacement -time graph gives the parabolic shape.

184. If acceleration of a particle at any time is given by

$$\mathbf{a = 2t + 5}$$

calculate the velocity after 5 s, if it starts from rest.

(a) 50 m/s
(b) 25 m/s
(c) 100 m/s
(d) 75 m/s

UP CPMT-2007

Ans. (a) : Given,

Initial velocity of the body (u) = 0 m/s

$t = 5s$

acceleration (a) = 2t + 5

As we know

$$\text{Acceleration (a)} = \frac{dv}{dt}$$

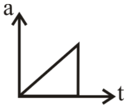
$$\int a\,dt = \int dv$$

$$\int_0^5 (2t+5)\,dt = \int_u^v dv$$

$$\left[t^2 + 5t\right]_0^5 = v - u \Rightarrow 5^2 + 5 \times 5 = v - 0$$

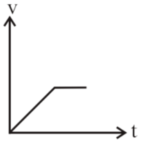
So, $v = 50$ m/s

185. The acceleration-time graph of a body is shown below

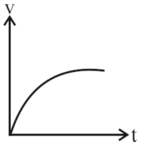


The most probable velocity-time graph of the body is

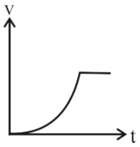
(a)



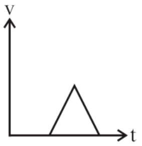
(b)



(c)

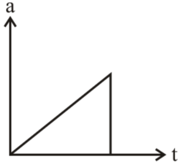


(d)



UP CPMT-2014

Ans. (c) : From the given figure, it is clear that acceleration is increasing at constant rate.



$$\therefore \quad \frac{da}{dt} = k$$

by integrating both side-

$$a = kt$$

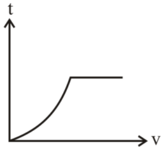
but we know that, $\frac{dv}{dt} = a$

$$\therefore \frac{dv}{dt} = kt \Rightarrow dv = kt.dt$$

$$\therefore \int dv = k\int t.dt$$

$$v = k.\ \frac{t^2}{2}$$

Therefore, v is depending on time parabolic and parabola is symmetric about v axis. After a certain point acceleration becomes zero i.e. velocity becomes constant. Hence option (c) is correct.



186. A body starts from the origin and moves along the X-axis such that velocity at any instant is given by ($4t^3$ – 2t), where t is in second and velocity is in m/s. What is the acceleration of the particle, when it is 2 m from the origin?

(a) 28 m/s^2
(b) 22 m/s^2
(c) 12 m/s^2
(d) 10 m/s^2

UP CPMT-2014

Ans. (b) : Given that,

velocity (v) = $4t^3 - 2t$

Therefore acceleration

$$a = \frac{dv}{dt} = 12t^2 - 2 \qquad \text{....(i)}$$

and

$$x = \int_0^t v\,dt = \int_0^t (4t^3 - 2t)dt$$

$$x = t^4 - t^2 \qquad \text{....(ii)}$$

From eqn. (ii) when particle is at 2m from origin then

$$x = 2$$

$$\because \quad t^4 - t^2 = 2$$

$$t^4 - t^2 - 2 = 0$$

$$(t^2 - 2)(t^2 + 1) = 0$$

@apna_pdf

$t=\sqrt{2}$ sec.

Now, Acceleration at $t = \sqrt{2}$

$a = 12t^2 - 2 = 12 \times 2 - 2$

$\boxed{a = 22 m/s^2}$

187. A trolley of mass 20 kg carries 5 kg grain and moves on a horizontal, smooth and straight track at 20 ms^{-1}. If the grain starts leaking out of a hole at the bottom at time t = 0, at rate 0.2 kgs^{-1}, the speed of the trolley at t = 10 s will be nearest to

(a) 20 ms^{-1} (b) 25 ms^{-1}

(c) 15 ms^{-1} (d) 13.3 ms^{-1}

UP CPMT-2014

Ans. (a) : As per given question

at t = 0 sec,

$M = m_1 + m_2 = 20 + 5 = 25$ kg

at t = 10 sec

$M' = M_1 + M_2 -$ rate of leakage × time

or, $M' = 20 + 5 - 0.2 \times 10$

$M' = 23$ kg

By law of conservation of momentum

Now, $Mv = M'v'$

$25 \times 20 = 23 \times v'$

$$v' = \frac{25 \times 20}{23}$$

$v' = 21.73$

$v' \approx 20$ m/s

188. The displacement of a body is given by 3s = a + $4bt^3$, where a and b are constants. What is the velocity of the body at the end of 1 s?

(a) 4b (b) a + 4b

(c) a – 4b (d) $a + \frac{4b}{3}$

UP CPMT-2014

Ans. (a) : Given,

$$3s = a + 4bt^3$$

$$s = \frac{1}{3}\left(a + 4bt^3\right)$$

$$\because \quad v = \frac{ds}{dt}$$

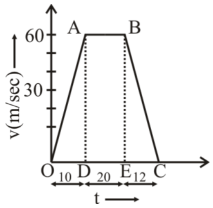
$$v = \frac{1}{3}\left(12bt^2\right) = 4bt^2$$

Now, at time t = 1s then

$v = 4b \times 1^2 = 4b$

So, velocity (v) = 4b

189. The velocity-time graph of a moving train is depicted in figure. The total distance covered by the train is

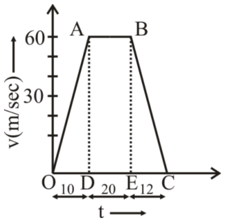


(a) 100m (b) 1860 m

(c) 9 m (d) 7.35 m

UP CPMT-2014

Ans. (b) :



Total distance travelled = Area of trapezium OABC

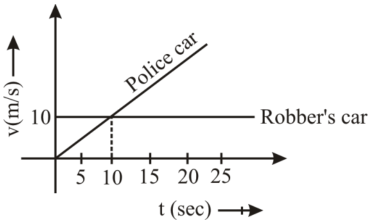
$$= \frac{1}{2}(OC + AB) \times AD$$

$$= \frac{1}{2}[(10 + 20 + 12) + 20] \times 60$$

$$= \frac{1}{2} \times 62 \times 60$$

$= 62 \times 30 = 1860$ m

190. The velocity-time graph of robber's car and a chasing police-car are shown in the following graph. Police car crosses the robber's car

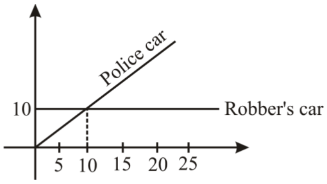


(a) 10 s after is starts (b) 15 s after it stars

(c) 20 s after it starts (d) Never crosses

UP CPMT-2013

Ans. (c) :



From graph, velocity of robber's car = 10 ms^{-1}

Let, Police car crosses it after t second distance travelled by robber's car = 10t m.

Police car is moving with a constant acceleration of 1ms^{-2} as it attains a velocity of 10ms^{-1} in 10sec after starting from rest.

Distance travelled in the t second.

$$\frac{1}{2}.a.t^2 = \frac{1}{2} \times 1 \times t^2 = \frac{1}{2}t^2$$

When the police car crosses the robber's Car, distance travelled by the both cars should be same from the starting point of cars.

$$\therefore \frac{1}{2}t^2 = 10t \Rightarrow t = 20 sec$$

@apna_pdf

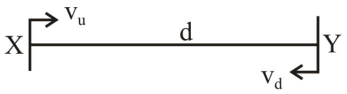
191. A car moves from X to Y with a uniform speed v_u and returns to Y with a uniform speed v_d. The average speed for this round trip is

(a) $\dfrac{2v_d v_u}{v_d + v_u}$ (b) $\sqrt{v_u v_d}$

(c) $\dfrac{v_d v_u}{v_d + v_u}$ (d) $\dfrac{v_u + v_d}{2}$

UP CPMT-2008

Ans. (a) :



$\therefore t = \dfrac{\text{distance}}{\text{time}}$

Time taken by car from X to Y

$$t_1 = \frac{d}{v_u}$$

Time taken by car from Y to X

$$t_2 = \frac{d}{v_d}$$

Average speed $= \dfrac{\text{Total distance}}{\text{Total time}}$

$$= \frac{d+d}{\dfrac{d}{v_u} + \dfrac{d}{v_d}} = \frac{2d}{d\left(\dfrac{1}{v_u} + \dfrac{1}{v_d}\right)}$$

Average speed, $V_{avg} = \dfrac{2v_u v_d}{v_u + v_d}$

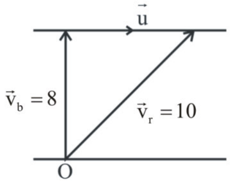
192. A boat is sent across a river with a velocity of 8 km/h. If the resultant velocity of boat is 10 km/h, then velocity of the river is

(a) 10 km/h (b) 8 km/h

(c) 6 km/h (d) 4 km/h

UP CPMT-2010

Ans. (c) : Velocity of boat



v_b = 8 km/hr

Resultant Velocity (v_r) = 10 km/hr

$$v_r^2 = u^2 + v_b^2$$

Velocity of river $(u) = \sqrt{v_r^2 - v_b^2}$

$$= \sqrt{(10)^2 - (8)^2} = 6\text{km/hr}$$

193. A point initially at rest moves along x-axis. Its acceleration varies with time as a = (6t + 5) m/s^2. If it starts from origin, the distance covered in 2 s is

(a) 20 m (b) 18 m

(c) 16 m (d) 25 m

UP CPMT-2006

Ans. (b) : Given, the acceleration of the particle varies with time as;

$$a = (6t + 5)\ \text{m/s}^2 \qquad .....(i)$$

Integrating the equation (i), we get–

$$\int(6t+5)dt = v$$

$$\frac{6t^2}{2} + 5t = v$$

$$3t^2 + 5t = v \qquad ....(2)$$

Now, given that the velocity of the particle varies with time as v = $(3t^2 + 5t)$ ms^{-1}.

Integrating the equation,

$$\int(3t^2 + 5t)dt = x$$

$$\frac{3t^3}{3} + \frac{5t^2}{2} = x \Rightarrow t^3 + \frac{5t^2}{2} = x$$

At, t = 2s

$$x = 2^3 + \frac{5\times 2^2}{2} = 18\text{ m}$$

194. If relation between distance and time is s = a + bt + ct^2, find initial velocity and acceleration.

(a) b + 2ct, 2c (b) b, 2c

(c) 2c, b (d) b + 2c, 2c

UP CPMT-2003

Ans. (b) : Given, if relation between distance and time is s = a + bt + ct^2

Differentiation both sides w.r.t time,

$$\frac{ds}{dt} = 0 + b + 2ct = b + 2ct$$

Initial velocity $= \left|\dfrac{ds}{dt}\right|_{t=0} = b + 2c\times 0$

$$= b + 0 = b$$

$\because$ Acceleration (a) $= \dfrac{dv}{dt} = 2c$

Initial acceleration $\left|\dfrac{dv}{dt}\right|_{t=0} = 2c$

Hence, initial velocity = b and initial acceleration = 2c

195. A ball is thrown upwards, it takes 4 s to reach back to the ground. Find its initial velocity

(a) 30 ms^{-1} (b) 10 ms^{-1}

(c) 40 ms^{-1} (d) 20 ms^{-1}

UP CPMT-2003

Ans. (d) : Given that,

Time (t) = 4 sec (for whole trip)

$\therefore$ Time to reach maximum height is half of total time

$$t_{max} = \frac{4}{2} = 2\sec$$

Also speed at maximum height is zero,

$\therefore$ Final velocity (v) = 0

We know that,

$$v = u - g\,t_{max}$$

$$u = 0 + 10 \times 2 = 20\text{ m/s}$$

@apna_pdf

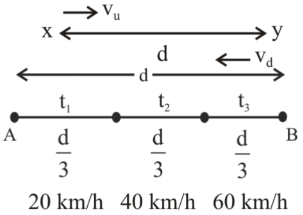
196. If the first one-third of a journey is travelled at 20 km/h, next one-third at 40 km/h and the last one-third at 60 km/h. The average speed of whole journey will be

(a) 32.7 km/h (b) 35 km/h

(c) 40 km/h (d) 45 km/h

UP CPMT-2002

Ans. (b) :



$$v = \frac{d}{t_1+t_2+t_3} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{d}{\frac{d}{3\times 20}+\frac{d}{3\times 40}+\frac{d}{3\times 60}}$$

$$= \frac{d}{\frac{d}{3\times 20}\left[\frac{1}{1}+\frac{1}{2}+\frac{1}{3}\right]}$$

$$= \frac{60}{1+\frac{1}{2}+\frac{1}{3}} = \frac{60}{\frac{6+3+2}{6}}$$

$$= \frac{60\times 6}{11} = \frac{360}{11}$$

$v = 32.7$ km/h

197. A particle is moving in a straight line along x-axis, its position is given by $x = 2t^2 + 2t + 4$ where, x is in metre and t in second, the acceleration of the particle is

(a) 2 m/s^2 (b) 4 m/s^2

(c) 6 m/s^2 (d) 8 m/s^2

UP CPMT-2001

Ans. (b) : Given, $x = 2t^2 + 2t + 4$

Differentiation w.r.to 't' both side,

$$v = \frac{dx}{dt} = 4t + 2 + 0 = 4t + 2$$

Again Differentiation w.r.t time,

$$a = \frac{d^2x}{dt^2} = 4\,\text{m/sec}^2$$

198. A car accelerates from rest with 2 m/s^2 on a straight line path and then comes to rest after applying brakes. Total distance travelled by the car is 100 m in 20 seconds. Then the maximum velocity attained by the car is

(a) 10 m/s (b) 20 m/s

(c) 15 m/s (d) 5 m/s

TS EAMCET (Engg.)-2016

Ans. (a) : By equation of motion,

$\because v = u - at$

$0 = u - a \times 20$

$u = 20a$ ..... (i)

and $v^2 - u^2 = 2(-a)s$

$0^2 - (20a)^2 = -2a \times 100$

$a = 0.5$ m/s^2

Now by equation (i),

$u = 20a = 20 \times 0.5 = 10$ m/s

199. A car starts from rest and starts moving on a circular path of radius 100 m such that its speed increases at the rate of 5 ms^{-2}. What is the radial acceleration of the car at the instant it makes one complete round trip (in m s^{-2})?

(a) 20 π (b) 10 π

(c) 40 π (d) 30 π

SRM JEE - 2007

Ans. (a) : The speed of the car after one complete round trip will be

$A = 5$ ms^{-2}

$v^2 = u^2 + 2as$

$v^2 = 2 \times 5\,(2\pi r)$ [$u = 0$ and $s = 2\pi r$]

$v^2 = 20\pi r$

Radial acceleration of the particle will be

$$a_r = \frac{v^2}{r} = \frac{20\pi r}{r} = 20\pi\,\text{m/s}^2$$

200. The position of a particle varies with time t as $x = at^2 - bt^3$. The acceleration of the particle will be zero at time t equal to

(a) $\frac{a}{b}$ (b) $\frac{2a}{b}$

(c) $\frac{a}{3b}$ (d) zero

SRM JEE - 2010

Ans. (c) : Position of a particle varies with time t as

$x = at^2 - bt^3$ ... (i)

Differentiating eq. (i) w.r.t. to time t, we get velocity

$$\frac{dx}{dt} = v = 2at - 3bt^2 \quad \text{... (ii)}$$

Differentiating eq. (ii) w.r.t. to time t, we get acceleration

$$\frac{dv}{dt} = 2a - 6bt$$

For acceleration to be zero, $2a - 6bt = 0$

$$\Rightarrow t = \frac{2a}{6b} = \frac{a}{3b}$$

201. The area under the acceleration time graph represents:

(a) the displacement (b) velocity

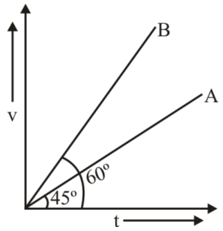
(c) change in velocity (d) distance travelled

SRM JEE - 2011

Ans. (c) : The area under an acceleration graph represents the change in velocity. In other words, the area under the acceleration graph for a certain time interval is equal to the change in velocity during that time interval.

@apna_pdf

202. The velocity time graphs of two bodies A and B are shown in figure. The ratio of their acceleration is



(a) $1:\sqrt{3}$
(b) 1 : 3
(c) $\sqrt{3}:1$
(d) $\sqrt{3}:\sqrt{2}$

SRM JEE - 2012

Ans. (a) : Slope of the velocity time graph gives acceleration (a)

$$\therefore \frac{a_A}{a_B}=\frac{\tan 45^\circ}{\tan 60^\circ}=\frac{1}{\sqrt{3}}$$

203. The position of a particle moving along x-axis is given by x = 3t – 4t^2 + t^3, Where x is in meter and t in seconds. The average velocity of the particle in the time interval from t = 2 seconds to t = 4 seconds is

(a) 7 m/s
(b) 1 m/s
(c) 13 m/s
(d) None of these

SRM JEE - 2012

Ans. (a) : Position of the particle is given by

$$x(t) = 3t - 4t^2 + t^3$$

Average velocity of the particle is

$$v_{avg}=\frac{x(t_2)-x(t_1)}{t_2-t_1} \qquad t_1 = 2, t_2 = 4$$

$$v_{avg}=\frac{x(4)-x(2)}{4-2}$$

Now, $x(4)=3(4)-4(4)^2+4^3=12\text{m}$

$$x(2)=3(2)-4(2)^2+2^3=-2\text{m}$$

$$\therefore v_{avg}=\frac{12-(-2)}{2}=\frac{14}{2}=7\text{m/s}$$

204. Which of the following four statements is false?

(a) A body can have zero velocity and still be accelerated
(b) A body can have a constant velocity and still have a varying speed
(c) A body can have a constant speed and still have a varying velocity
(d) The direction of the velocity of a body can change when its acceleration is constant

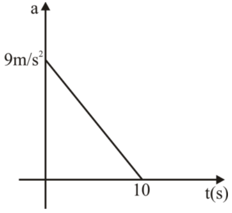
SRM JEE - 2012

Ans. (b) : When a body is projected vertically upwards, at highest point velocity is zero but still accelerated downwards.

In uniform circular motion a body has constant speed and still have a varying velocity.

In projectile motion direction of the velocity of a body changes, when its acceleration is constant.

205. A particle starts from rest. Its acceleration (a) versus time (t) is as shown in the figure. The maximum speed of the particle will be



(a) 110 m/s
(b) 45 m/s
(c) 900 m/s
(d) 90 m/s

SRM JEE - 2013

Ans. (b) : Area under the acceleration time graph will give maximum speed of the particle.

$$v_{max}=\frac{1}{2}\times\text{base}\times\text{height}$$

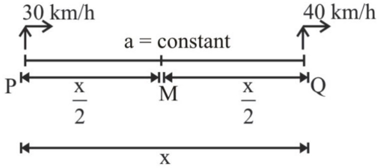
$$v_{max}=\frac{1}{2}\times 10\times 9=45\text{m/s}$$

206. A car is moving along a straight road with a uniform acceleration. It passes through two points P and Q separated by a distance with velocity 30 km/h and 40 km/h respectively. The velocity of the car midway between P and Q is

(a) 33.3 km/h
(b) $20\sqrt{2}$ km/h
(c) $25\sqrt{2}$ km/h
(d) 0.35 km/h

[AIPMT 1988]

Ans. (c) :
By using the equation of motion b/w point P and M,



$$v^2 = u^2 + 2as$$

$\Rightarrow \quad v^2 = (30)^2 + 2as$

$\Rightarrow \quad v^2 - (30)^2 = 2as$

$\Rightarrow \quad v^2-900=2a\frac{x}{2}$

$\Rightarrow \quad v^2 - 900 = ax$

$$a=\frac{v^2-900}{x} \qquad \ldots\ldots\text{(i)}$$

Using equation of motion between point M and Q,

$$(40)^2=v^2+2a\frac{x}{2}$$

$$1600 = v^2 + ax$$

$$a=\frac{1600-v^2}{x} \qquad \ldots\ldots\text{(ii)}$$

From equation (i) and (ii)

$$\frac{v^2-900}{x}=\frac{1600-v^2}{x}$$

$$2v^2 = 2500$$

$$v^2=\frac{2500}{2}$$

@apna_pdf

$$v = \sqrt{\frac{2500}{2}}$$

$$v = \frac{50}{\sqrt{2}}$$

Multiplying by $\sqrt{2}$

$$v = \frac{50 \times \sqrt{2}}{\sqrt{2} \times \sqrt{2}}$$

$$v = \frac{50\sqrt{2}}{2}$$

$v = 25\sqrt{2}$ km/h

207. The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}$ ms^{-2}, in the third-second is

(a) 6 m (b) 4 m

(c) $\frac{10}{3}$ m (d) $\frac{19}{3}$ m

[AIPMT 2008]

Ans. (c) : Given - $n = 3,\ u = 0,\ a = \frac{4}{3} m/s^2$

Distance travelled by the particle in nth second

$$S_{n^{th}} = u + \frac{1}{2}a(2n-1)$$

Where u is initial speed and a is acceleration of the particle.

Put the value of n, u and 'a'

$$\therefore \quad S_{3^{rd}} = 0 + \frac{1}{2} \times \frac{4}{3} \times (2 \times 3 - 1)$$

$$= 0 + \frac{2}{3} \times (6-1) = \frac{2}{3} \times 5$$

$$S_{3^{rd}} = \frac{10}{3} m$$

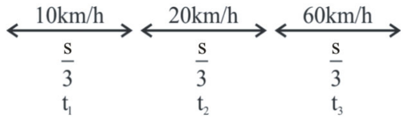
208. A bus travelling the first one-third distance at a speed of 10 km/h, the next one-third at 20 km/h and the last one-third at 60 km/h. The average speed of the bus is

(a) 9 km/h (b) 16 km/h

(c) 18 km/h (d) 48 km/h

[AIPMT 1991]

Ans. (c) :



$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$\text{Average speed} = \frac{s}{t_1 + t_2 + t_3}$$

$$= \frac{s}{\frac{\frac{s}{3}}{10} + \frac{\frac{s}{3}}{20} + \frac{\frac{s}{3}}{60}}$$

$$= \frac{s}{\frac{s}{3}\left[\frac{1}{10} + \frac{1}{20} + \frac{1}{60}\right]} = \frac{1}{\frac{1}{3}\left(\frac{1}{10} + \frac{1}{20} + \frac{1}{60}\right)}$$

$$= \frac{1}{\left(\frac{1}{30} \times \frac{10}{6}\right)} = 18 \text{ km/h}$$

The average speed of the bus = 18 km/h

209. A car moves a distance of 200 m. It covers the first-half of the distance at speed 40 km/h and the second-half of distance at speed v km/h. The average speed is 48 km/h. Find the value of v.

(a) 56 km/h (b) 60 km/h

(c) 50 km/h (d) 48 km/h

[AIPMT 1991]

Ans. (b) : Given data,

Distance = 200m

Speed in 1st half distance = 40 km/h

Average speed = 48km/h

$$\therefore \quad \text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$48 = \frac{200}{\frac{100}{40} + \frac{100}{v}}$$

$$\frac{1}{40} + \frac{1}{v} = \frac{1}{24}$$

$$v = \frac{120}{5-3} \Rightarrow v = \frac{120}{2}$$

v = 60 km/h

210. A car covers the first-half of the distance between two places at 40 km/h and other half at 60 km/h. The average speed of the car is

(a) 40 km/h (b) 48 km/h

(c) 50 km/h (d) 60 km/h

[AIPMT 1990]

Ans. (b) : Given,

Speed in first half, $v_1 = 40$ km/h

Speed in second half, $v_2 = 60$ km/h

$\because$ Car covers equal distance with different speeds.

$$\therefore \quad \text{Average speed of car } (v_{av}) = \frac{2v_1 \times v_2}{v_1 + v_2}$$

$$= \frac{2 \times 40 \times 60}{40 + 60}$$

$$= \frac{4800}{100}$$

= 48 km/h

@apna_pdf

211. A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-2n}$ where, β and n are constants and x is the position of the particle. The acceleration of the particle as a function of x, is given by

(a) $-2n\beta^2 x^{-2n-1}$ (b) $-2n\beta^2 x^{-4n-1}$
(c) $-2\beta^2 x^{-2n+1}$ (d) $-2n\beta^2 e^{-4n+1}$

[AIPMT 2015]

Ans. (b) : Given,
The velocity of the particle, $v(x) = \beta x^{-2n}$
We know,

$$\text{Acceleration, } a = \frac{dv}{dt}$$

$$a = \frac{dv}{dt} \times \frac{dx}{dx}$$

$$a = \frac{dv}{dx} \times \frac{dx}{dt}$$

$$\because \text{Velocity (v) } = \frac{dx}{dt}$$

Thus,

$$a = v\frac{dv}{dx} \quad \text{.......(i)}$$

$$\because v(x) = \beta x^{-2n}$$

Differentiating v with respect to x, we get

$$\frac{dv}{dx} = -2n\beta x^{-2n-1}$$

Now, from equation (i)

$$a = v\frac{dv}{dx}$$

$$\Rightarrow a = \beta x^{-2n} \times \left(-2n\beta x^{-2n-1}\right)$$

$$\Rightarrow a = -2n\beta^2 x^{-2n-1-2n}$$

$$a = -2n\beta^2 x^{-4n-1}$$

212. The motion of a particle along a straight line is described by equation $x = 8 + 12t - t^3$ where, x is in metre and t in sec. The retardation of the particle when its velocity becomes zero, is

(a) 24 ms^{-2} (b) zero
(c) 6 ms^{-2} (d) 12 ms^{-2}

[AIPMT 2012]

Ans. (d) : Given,

$$x = 8 + 12t - t^3 \qquad a = ? \quad v = 0$$

Differentiation,

$$\frac{dx}{dt} = 0 + 12 - 3t^2$$

$$v = \frac{dx}{dt} = 12 - 3t^2 \quad \text{......(i)}$$

$$0 = 12 - 3t^2 \qquad \{\because v = 0\}$$

$$\Rightarrow 3t^2 = 12$$

$$t^2 = \frac{12}{3}$$

$$t^2 = 4$$

$$t = 2 \text{ sec}$$

From equation (i)

$$\therefore \text{Acceleration (a) } = \frac{dv}{dt} = \frac{d}{dt}\left(12 - 3t^2\right)$$

$$= 0 - 3 \times 2t = -6t$$

$$a = -6t \quad \text{.......(ii)}$$

Putting the value of t in equation (ii)

$$a = -6 \times 2$$

$$a = -12 \text{ m/s}^2$$

$$\Rightarrow \quad a = 12 \text{ m/s}^2 \text{ (retardation)}$$

213. A body is moving with velocity 30 m/s towards East. After 10s, its velocity becomes 40m/s towards North. The average acceleration of the body is

(a) 7 m/s^2 (b) $\sqrt{7} \text{m/s}^2$
(c) 5 m/s^2 (d) 1 m/s^2

[AIPMT 2011]

Ans. (c) : Given :

$$\text{Velocity, } \left(v\hat{i}\right) = 30 \text{ m/s}$$

$$\text{Velocity, } \left(v\hat{j}\right) = 40 \text{ m/s}$$

$$\text{Time} = \left(\Delta t\right) = 10 \text{ second}$$

$$\text{Average acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

$$a = \frac{\left|v\hat{i} - v\hat{j}\right|}{\Delta t}$$

$$a = \frac{\sqrt{(30)^2 + (40)^2}}{10}$$

$$a = \frac{\sqrt{900 + 1600}}{10}$$

$$a = \frac{\sqrt{2500}}{10}$$

$$a = \frac{50}{10}$$

$$a = 5 \text{ m/s}^2$$

Hence, the average acceleration of the body is 5 m/s^2

214. A particle moves a distance x in time t according to the equation $x = (t + 5)^{-1}$. The acceleration of particle is proportional to

(a) $(\text{velocity})^{3/2}$ (b) $(\text{distance})^2$
(c) $(\text{distance})^{-2}$ (d) $(\text{velocity})^{2/3}$

[AIPMT 2010]

Ans. (a) : Given
Distance, $x = (t+5)^{-1}$ ...(i)
Differentiating equation (i) w.r.t 't' we get,

$$\frac{dx}{dt} = v = \frac{-1}{(t+5)^2} \quad \text{...(ii)}$$

Again, differentiating equation (ii) w.r.t 't' we get,

$$\frac{d^2x}{dt^2} = (a) = \frac{2}{(t+5)^3} \quad \text{....(iii)}$$

Comparing equation (ii) and (iii), we get

$$a \propto v^{3/2}$$

@apna_pdf

215. A bus is moving with a speed of 10 ms^{-1} on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what speed should the scooterist chase the bus?

(a) 20 ms^{-1} (b) 40 ms^{-1}

(c) 25 ms^{-1} (d) 10 ms^{-1}

[AIPMT 2009]

Ans. (a) : Given, distance = 1km = 1000m.

Velocity of bus, $v_B = 10 m/s$

Let us assume the velocity of scooter is v_s.

Distance covered by scooterist in 100s = Position of the bus at 100s

$$= (1000 + x)$$

Distance covered by scooterist in (100s)

$$\Rightarrow x = 100 \times 10 = 1000m$$

Velocity of the scooter:

$$1000m + 1000m = 100 \times v_s$$

$$v_s = \frac{2000}{100}$$

$$v_s = 20 \text{ m/s}$$

216. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $X_P(t) = at + bt^2$ and $X_Q(t) = ft - t^2$. At what time do the cars have the same velocity?

(a) $\frac{a-f}{1+b}$ (b) $\frac{a-f}{2(b-1)}$

(c) $\frac{a-f}{2(1+b)}$ (d) $\frac{f-a}{2(1+b)}$

[NEET 2016]

Ans. (d) : Given: $X_P(t) = at + bt^2$ ...(i)

And $X_Q(t) = ft - t^2$ ….(ii)

Differentiating eqn (i) and (ii) w.r.t 't' we get,

$$v_P = \frac{d[X_P(t)]}{dt} = \frac{d(at+bt^2)}{dt} = a + 2bt \quad ...(iii)$$

$$v_Q = \frac{d[X_Q(t)]}{dt} = \frac{d(ft-t^2)}{dt} = f - 2t \quad ...(iv)$$

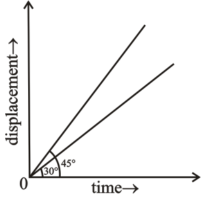
Let at time 't_0' the cars have same velocity

$$[v_P]_{t=t_0} = [v_Q]_{t=t_0}$$

$$\Rightarrow a + 2bt_0 = f - 2t_0$$

$$\Rightarrow t_0 = \frac{f-a}{2(1+b)}$$

217. The displacement-time graphs of two moving particles make angles of 30° and 45° with the x-axis as shown in the figure. The ratio of their respective velocity is



(a) 1 : 2 (b) $1:\sqrt{3}$

(c) $\sqrt{3}:1$ (d) 1 : 1

K CET-2011

Ans. (b) : Given,

$\theta_1 = 30°$ $\theta_2 = 45°$

We know that,

Velocity = slope of x – t graph

$v = \tan\theta$

$\therefore$ $v_1 = \tan 30°$

$$v_1 = \frac{1}{\sqrt{3}}$$

$v_2 = \tan 45°$

$v_2 = 1$

$$\frac{v_1}{v_2} = \frac{\frac{1}{\sqrt{3}}}{1}$$

$v_1 : v_2 = 1:\sqrt{3}$

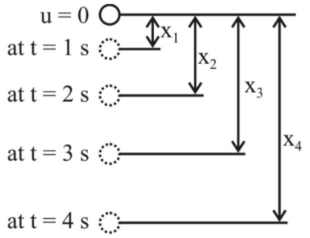
218. The ratio of the distances travelled by a freely falling body in the 1st, 2nd, 3rd and 4 the second

(a) 1:3:5:7 (b) 1:1:1:1

(c) 1:2:3:4 (d) 1:4:9:16

NEET-2022

Ans. (a):



Since initial velocity of freely falling body is zero.

Then distance travelled by the body –

$$s = ut + \frac{1}{2}gt^2$$

$$s = 0 + \frac{1}{2}gt^2 \qquad [\because g = \text{constant}]$$

$$\therefore \qquad s \propto t^2$$

Now distance travelled by the body in 1s

$s_1 = x_1 = kt^2 \Rightarrow s_1 = k(1)^2 \Rightarrow s_1 = k$ ….(i)

Distance travelled by body in 2 sec.

$s_2 = (x_2 - x_1) = k(2)^2 - k(1)^2$

$s_2 = 4k - k = 3k$ ….(ii)

And just like above process-

$s_3 = (x_3 - x_2) = k(3)^2 - k(2)^2$

$s_3 = 9k - 4k = 5k$ ….(iii)

$s_4 = (x_4 - x_3) = k(4)^2 - k(3)^2$

$s_4 = 16k - 9k = 7k$ ….(iv)

From equation (i), (ii), (iii) and (iv)

$s_1 : s_2 : s_3 : s_4 = 1 : 3 : 5 : 7$

@apna_pdf

219. The weight of an object is 90 kg at the surface of the earth. If it is taken to a height equal to half of the radius of the earth, then its weight will become:

(a) 135 kg
(b) 45 kg
(c) 60 kg
(d) 40 kg

MP PMT-2013

Ans. (d): We know

$$g_h = \frac{g}{(1+h/r)^2}$$

Now, h = R/2

$$g_h = \frac{g}{(1+R/2R)^2}$$

$$g_h = \frac{4}{9}g$$

Multiplying with mass both sides.

$$mg_h = \frac{4}{9}mg$$

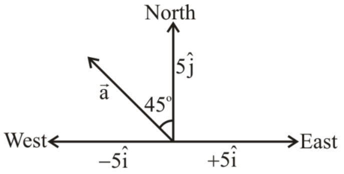
$$\frac{4}{9}\times 90 = 40\text{kg}$$

220. A particle is moving eastwards with a velocity of 5 m/sec. If in 10 s the velocity changes by 5 m/s northwards, what is the average acceleration in this time ?

(a) $\frac{1}{\sqrt{2}}\text{m/s}^2$ (North-west)
(b) $\frac{1}{\sqrt{2}}\text{m/s}^2$ (North-east)
(c) $\sqrt{2}\text{m/s}^2$ (North-west)
(d) $\sqrt{2}\text{m/s}^2$ (North-east)

MP PMT-2013

Ans. (a) : Initial velocity (u) = 5 m/s due east
Final velocity (v) = 5 m/s due north



Now, change in velocity = $\vec{v}-\vec{u}$

$|\Delta v| = (v^2+u^2)^{1/2} = \sqrt{5^2+5^2}$

$\Rightarrow \Delta v = 5\sqrt{2}\text{m/s}$

Direction of Δv is given by,

$$\tan = \frac{v}{u} = \frac{5}{-5} = -1$$

$\Rightarrow \theta = -\pi/4$

Thus, the acceleration is

$$a = \frac{\Delta v}{t} = \frac{5\sqrt{2}}{10}$$

$a = \frac{1}{\sqrt{2}}\text{m/s}^2$ and is directed towards North-West direction

221. The relation between the 't' and distance 'x' is t = $\alpha x^2+\beta x$, where α & β are constants. The retardation is:

(a) $2\alpha.v^3$
(b) $2\beta.v^3$
(c) $2\alpha\beta.v^3$
(d) $2\beta^2v^3$

MP PET-2012

Ans. (a) : The relation

$$t = \alpha x^2+\beta x$$

Differentiate w.r.t time

$$1 = 2\alpha x\frac{dx}{dt}+\beta\frac{dx}{dt}$$

$$v = \frac{dx}{dt} = \frac{1}{2\alpha x+\beta} \quad \text{..........(i)}$$

$$a = \frac{dv}{dt} = v.\frac{dv}{dx} = \frac{1}{2\alpha x+\beta}\times\frac{-2\alpha}{(2\alpha x+\beta)^2}$$

$$a = \frac{-2\alpha}{(2\alpha x+\beta)^3} = \frac{1}{(2\alpha x+\beta)^3}\times(-2\alpha)$$

$a = -2\alpha v^3$ [from (i)]

∵ So retardation = $2\alpha v^3$

222. A car traveling on a straight path moves with uniform velocity v_2 for some time and with velocity v_2 of next equal time, the average velocity is given by

(a) $\sqrt{v_1v_2}$
(b) $\left(\frac{v_1+v_2}{2}\right)$
(c) $\left(\frac{1}{v_1}+\frac{1}{v_2}\right)^{-1}$
(d) $2\left(\frac{1}{v_1}+\frac{1}{v_2}\right)^{1}$

MP PMT-2009

Ans. (b) : Average velocity $= \frac{\text{Total Displacement}}{\text{Total time}}$

Displacement in first instant = v_1 t
Displacement in second instant = v_2 t

$$\therefore \text{ Average velocity} = \frac{v_1t+v_2t}{t+t}$$

$$\text{Average velocity } = \frac{v_1+v_2}{2}$$

223. A particle is projected with velocity V_0 along x-axis. The deceleration on the particle is proportional to the square of the distance from the origin i.e. a = αx^2, the distance at which the particle stops is

(a) $\sqrt{\frac{3V_0}{2\alpha}}$
(b) $\left(\frac{3V_0}{2\alpha}\right)^{\frac{1}{3}}$
(c) $\sqrt{\frac{2V_0^2}{3\alpha}}$
(d) $\left(\frac{3V_0^2}{2\alpha}\right)^{\frac{1}{3}}$

MP PET-2008

@apna_pdf

Ans. (d) : We know that

$$a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx} = -\alpha x^2$$

$\Rightarrow \qquad vdv = -\alpha x^2 dx$

When particle will stop velocity of particle will be zero and it stop at distance (s).

$$\therefore \qquad \int_{V_0}^{0} vdv = -\alpha\int_0^s x^2 dx$$

$$\frac{v_0^2}{2} = \frac{\alpha s^3}{3}$$

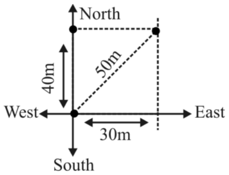
$$\therefore \qquad s = \left(\frac{3v_0^2}{2\alpha}\right)^{1/3}$$

224. A particle moves towards east for 2 s with velocity 15 m/s and move towards north for 8 s with velocity 5 m/s. Then, average velocity of the particle is

(a) 1 m/s (b) 5 m/s
(c) 7 m/s (d) 10 m/s

JIPMER-2014

Ans. (b) : Average velocity $= \frac{\text{Total Displacement}}{\text{Total time}}$



Particle moves towards east for 2s with velocity 15m/s. So, displacement of particle in east direction = velocity x time

$s_1 = 15 \times 2 = 30$ m

When particle move towards north for 8 second with the velocity 5 m/s.

So displacement of particle in north direction-

$s_2 = 5 \times 8$

$s_2 = 40$ m

Resultant displacement of particle $= \sqrt{(30)^2 + (40)^2}$

$s_R = \sqrt{900+1600} = \sqrt{2500}$

$s_R = 50$ m

Average velocity $(v) = \frac{s_R}{t_1 + t_2}$

$$v = \frac{50}{2+8}$$

$$v = \frac{50}{10} m/s$$

v = 5 m/s

225. A boy on a cycle pedals around a circle of 20 meters radius at a speed of 20 m/s. The combined mass of the body and the cycle makes angle θ with the vertical so that it may not fall. The value of θ is ($g = 9.8 m/s^2$)

(a) 60.25° (b) 63.90°
(c) 26.12° (d) 30.00°

JIPMER-2012

Ans. (b) : Given that

v = 20 m/sec

radius = 20 m

$g = 9.8$ m/sec^2

Angle made by boy with vertical is θ-

Then,

$$\tan\theta = \frac{\frac{mv^2}{r}}{mg}$$

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan\theta = \frac{(20)^2}{20 \times 9.8} = \frac{400}{196}$$

$\tan\theta = 2.04$

$\theta = 63.90^\circ$

226. A police party is moving in jeep at a constant' speed V, They saw a thief at a distance z on a motorcycle which is at rest. The moment the police saw the thief, the thief started at constant acceleration a which of the following relations is true if the police is able to catch the thief?

(a) $V^2 < ax$ (b) $V^2 < 2ax$
(c) $V^2 \geq 2ax$ (d) $V^2 = ax$

JIPMER-2012

Ans. (c): Distance travelled by thief in time t is

$$s = \frac{1}{2}at^2 \qquad ....(i)$$

To catch the thief distance travelled by police in time t is–

$$s + x = vt \qquad ....(ii)$$

From (i) and (ii) –

$$x = vt - \frac{1}{2}at^2$$

$2x = 2vt - at^2$

$at^2 - 2vt + 2x = 0$

$$t = \frac{2v \pm \sqrt{4v^2 - 4.a.2x}}{2a}$$

For real t–

$4v^2 - 8ax \geq 0$

$v^2 \geq 2ax$

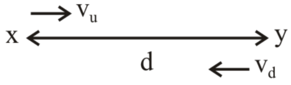
227. A car moves from X to Y with a uniform speed v_u and returns to Y with a uniform speed v_d. The average speed for this round trip is

(a) $\frac{2v_d v_u}{v_d + v_u}$ (b) $\sqrt{v_d + v_d}$
(c) $\frac{v_d v_u}{v_d + v_u}$ (d) $\frac{v_d + v_u}{2}$

JIPMER-2009

@apna_pdf

Ans. (a) :



$$t_x = \frac{d}{v_u}$$

$$t_y = \frac{d}{v_d}$$

Total time for round trip = $t_x + t_y$.

$$\text{Average Speed} = \frac{\text{total distance}}{\text{Total time of journy.}}$$

$$v = \frac{2d}{t_x + t_y}$$

$$v = \frac{2d}{\frac{d}{v_u} + \frac{d}{v_d}}$$

$$v = \frac{2v_d v_u}{v_d + v_u}$$

228. A car starts from rest, moves with an acceleration a and then decelerates at a constant rate b for sometimes to come to rest. If the total time taken is t. The maximum velocity of car is given by:

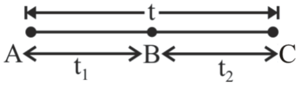
(a) $\frac{abt}{(a+b)}$ (b) $\frac{a^2t}{a+b}$

(c) $\frac{at}{(a+b)}$ (d) $\frac{b^2t}{a+b}$

JIPMER-2005

Ans. (a) : Let the car travels with accelerates 'a' for t_1 sec. and car decelerates with acceleration 'b' for t_2 second.

Let the maximum velocity of car in whole journey be v.



Since total time taken by the car in whole journey is t.

$\therefore \quad t_2 = (t - t_1)$

Using the Newton's 1st law of motion for A to B

$v = u + at$

$\because u = 0$, and $t = t_1$

$\therefore v = 0 + at$

$$t_1 = \frac{v}{a} \qquad \ldots(i)$$

Again for B to C –

$v = u + at$

$\because v = 0$ at C,

$a = -b, t = t_2$

And $u = v$

$\therefore 0 = v - bt_2 \Rightarrow v = b(t - t_1) \qquad \ldots(ii)$

From equation (i) and (ii)

$$v = b\left(t - \frac{v}{a}\right) \Rightarrow \frac{v}{b} = \left(t - \frac{v}{a}\right)$$

$$v\left(\frac{a+b}{ab}\right) = t$$

$$v = \frac{abt}{a+b}$$

229. A police jeep is chasing with velocity of 45 km/h. A thief in another jeep moving with velocity 153 km/h. Police fires a bullet with muzzle velocity of 180 m/s. The velocity it will strike the car the thief is

(a) 150 m/s (b) 27 m/s

(c) 450 m/s (d) 250 m/s

JIPMER-2005

Ans. (a) : Given,

Velocity of police Jeep = 45 km/h

$$= 45 \times \frac{5}{18} = 12.5\,\text{m/s}$$

Velocity of thief Jeep = 153 km/h

$$= 153 \times \frac{5}{18} = 42.5\,\text{m/s}$$

Muzzle velocity = 180 m/s

Effective speed of the bullet = speed of bullet + speed of police Jeep

$= (180 + 12.5)$m/s

$= 192.5$ m/s

Speeds of thief's Jeep = 42.5 m/s

Velocity of bullet with respect to thief's car

$= 192.5 - 42.5 = 150$ m/s

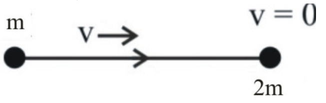
230. A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. The speed of the system, will be

(a) 3v (b) $\frac{v}{2}$

(c) $\frac{v}{3}$ (d) 2v

JIPMER-2004

Ans. (c): Given data,



$m_1 = m \qquad u_1 = v$

$m_2 = 2m \qquad u_2 = 0$

Now,

Law of conversion of linear momentum

$$m_1u_1 + m_2u_2 = (m_1 + m_2)V \qquad \ldots(i)$$

Putting value in equation (i)

$m \times v + 2m \times 0 = (m + 2m)\,V$

$mv = (3m)V$

$$V = \frac{mv}{3m}$$

$$V = \frac{v}{3}$$

@apna_pdf

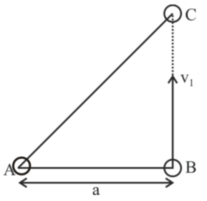
231. Two boys are standing at the ends A and B of a ground, where AB = a. The boy at B starts running in a direction perpendicular to AB with velocity v_1. The boy at A starts running simultaneously with velocity v and catches the other boy is a time t, where t is

(a) $\frac{a}{\sqrt{v^2+v_1^2}}$ (b) $\sqrt{\frac{a^2}{v^2-v_1^2}}$

(c) $\frac{a}{\left(v^2-v_1\right)}$ (d) $\frac{a}{\left(v+v_1\right)}$

JIPMER- 2007

Ans. (b) :



$BC = v_1 \times t$

$AC = v \times t$

$\therefore \quad AC^2 = AB^2 + BC^2$

$(vt)^2 = a^2 + (v_1 \times t)^2$

$v^2t^2 = a^2 + v_1{}^2 \times t^2$

$v^2t^2 - v_1{}^2t^2 = a^2$

$t^2(v^2 - v_1{}^2) = a^2$

$t = \sqrt{\frac{a^2}{(v^2-v_1^2)}}$

232. The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will

(a) go on decreasing with time

(b) be independent of α and β

(c) drop to zero when α = β

(d) go on increasing with time

JIPMER- 2007

Ans. (d) : Given,

$x = ae^{-\alpha t} + be^{\beta t}$

Differentiating w.r.t. t, we get

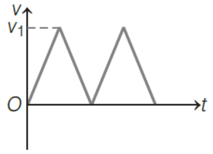
$\frac{dx}{dt} = ae^{-\alpha t}(-\alpha) + be^{\beta t}.\beta$

$v = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$

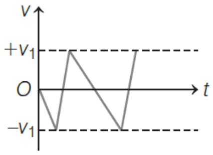
From the above equation we can tell that velocity will increase with time since the negative component will decrease with an increase in time and the positive component will increase in the given equation.

233. Consider a rubber ball freely falling from a height h = 4.9 m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic. Then, the velocity as a function of time the height as function of time will be

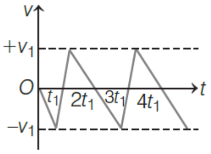
(a)



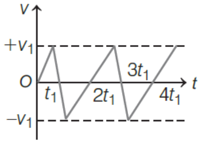
(b)



(c)



(d)



AIEEE 2009

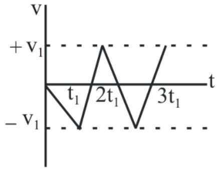
Ans. (c) : For vertical motion,

$h = \frac{1}{2}gt^2\,(\text{parabolic})$

v = –gt and after the collision

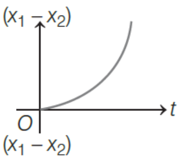
v = gt (straight line)

Collision is perfectly elastic, then ball reaches to same height again and again with same velocity.

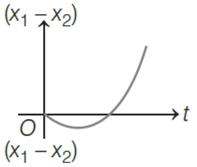


234. A body is at rest at x = 0. At t = 0, it starts moving in the positive x-direction with a constant acceleration. At the same instant, another body passes through x = 0 moving in the positive x-direction with a constant speed. The position of the first body is given by x_1 (t) after time t and that of the second body by x_2 (t) after the same time interval. Which of the following graphs correctly describes ($x_1 - x_2$) as a function of time?

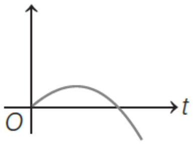
(a)



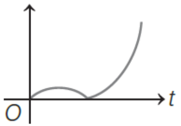
(b)



(c)



(d)



AIEEE 2008

Ans. (b) : for body (1)

u = 0, x = 0, t = 0

a = constant

$x_1 = ut + \frac{1}{2}at^2$

$x_1 = \frac{1}{2}at^2$

For body – 2,

Speed = v_2 (Constant)

$x_2 = v_2$ t

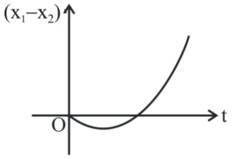
@apna_pdf

$\therefore x_1 - x_2 = \frac{1}{2}at^2 - v_2t$ (parabola concave)

From the above expression it is clear that at t = 0, $x_1 - x_2 = 0$ further for increasing values

$$\frac{1}{2}at^2 - v_2t = 0$$

$$t = 0, t = \frac{2v_2}{a}$$



235. An object moving with a speed of 6.25 m/s, is decelerated at a rate given by $dv/dt = -2.5\sqrt{v}$ where v is the instantaneous speed(d) The time taken by the object to come to rest, would be

(a) 2 s
(b) 4 s
(c) 8 s
(d) 1 s

AIEEE 2011

Ans. (a) : Given,

t = 0, v = 6.25 m/s

t = t, v = 0

$$\frac{dv}{dt} = -2.5\sqrt{v}$$

$$\frac{dv}{\sqrt{v}} = -2.5dt \Rightarrow \int_{6.25}^{0} (V)^{-1/2} = -2.5\int_0^t dt$$

$$\left|2\sqrt{v}\right|_{6.25}^{0} = -2.5\left|t\right|_0^t$$

$$2\sqrt{6.25} = 2.5t \Rightarrow t = \frac{2\times 2.5}{2.5} = 2\sec$$

236. The equation of motion of a body is $\frac{dv(t)}{dt} = 9 - 3v(t)$, where ν (t), where ν(t) is the speed (in m/s) at time t (in second). If the body was at rest at t = 0, then which of the following is correct?

(a) The terminal speed is 3 m/s
(b) Initial acceleration is 9 m/s^2
(c) $v(t) = 3(1 - e^{-3t})$
(d) All of these are correct

Assam CEE-2016

Ans. (d) : Given,

$$\frac{dv(t)}{dt} = 9 - 3v(t)$$

$$dv = [9 - 3v(t)]dt$$

$$\frac{dv}{9 - 3v(t)} = dt$$

Integrating both side of above equation, we get

$$\int_0^v \frac{dv}{9 - 3v(t)} = \int_0^t dt$$

$$\left[\frac{\ln[9 - 3v]}{-3}\right]_0^v = t$$

$$\ln(9 - 3v) - \ln 9 = -3t$$

$$\ln\left[\frac{9 - 3v}{9}\right] = -3t$$

$$\ln\left(1 - \frac{v}{3}\right) = -3t$$

$$1 - \frac{v}{3} = e^{-3t}$$

$$\frac{v}{3} = 1 - e^{-3t}$$

$$v = 3(1 - e^{-3t})$$

(ii) The terminal speed I the constant speed when acceleration is zero.

Thus, $0 = 9 - 3v$

$v = 3$ m/s

(iii) at t = 0, v = 0

∴ initial acceleration a = 9 – 0 = 9 m/s^2

237. A particle moves in the x-y plane with velocity v_x = 8t – 2 and v_y = 2. If it passes through the point x = 14 and y = 4 at t = 2 s, then the equation of the path will be

(a) $x = y^2 - y + 2$
(b) $x = 2y^2 + 2y - 3$
(c) $x = 3y^2 + 5$
(d) None of the above

Assam CEE-2014

Ans. (d) : Given,

$$v_x = 8t - 2$$

$$\frac{dx(t)}{dt} = 8t - 2$$

$$x(t) = \frac{8t^2}{2} - 2t + x(0)$$

$$x(t) = 4t^2 - 2t + x(0) \quad ....(i)$$

Condition, x = 14 at t= 2

$x(2) = 4\times(2)^2 - 2\times2 + x(0)$

$14 = 16 - 4 + x(0)$

$\Rightarrow x(0) = 2$

∴ equation (i) becomes, we get

$x(t) = 4t^2 - 2t + 2 \quad …(ii)$

Now,

$$v_y = 2$$

$$\frac{dy(t)}{dt} = 2$$

$y(t) = 2t + y(0) \quad …(iii)$

Condition, y = 4 at t = 2s,

$y(4) = 2\times2 + y(0)$

$4 = 4 + y(0)$

$\Rightarrow y(0) = 0$

@apna_pdf

$\therefore$ Equation (iii) becomes, wet get,

$y(t) = 2t$

$t = y/2$

$\therefore$ equation (ii) becomes

$$x\,(y/2) = 4\left(\frac{y}{2}\right)^2 - 2\left(\frac{y}{2}\right) + 2$$

$x(t) = y^2 - y + 2$

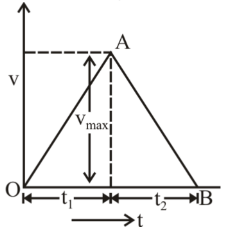
238. Engine of a vehicle can give it an acceleration of 1 m/s², while the brake of the vehicle can retard it at 8 m/s². Then the minimum time in which the vehicle can complete a journey of 600 m will be.

(a) 80s (b) 60 s

(c) 40 s (d) None of the above

Assam CEE-2014

Ans. (c) : Area of the curve gives total distance



$$\frac{1}{2}\times v_{max}\times t_1 + \frac{1}{2}\times v_{max}\times t_2 = 600$$

$v_{max} = at_1$

$v_{max} = 1 \times t_1 = t_1$

$$\frac{1}{2}\times t_1\times t_1 + \frac{1}{2}t_1t_2 = 600$$

$$\frac{1}{2}\times t_1^2 + \frac{1}{2}t_1t_2 = 600 \qquad \ldots(i)$$

$v = v_{max} - \beta\, t_2$

$0 = v_{max} - 8\, t_2$

$v_{max} = 8\, t_2$

$t_1 = 8\, t_2 \qquad \ldots(ii)$

From equation (i) and (ii)

$$\frac{1}{2}(8t_2)^2 + \frac{1}{2}\times(8t_2)(t_2) = 600$$

$64t_2^2 + 8t_2^2 = 1200$

$72t_2^2 = 1200$

$$t_2 = \sqrt{\frac{100}{6}} = 4.08 \text{ sec}$$

$t_1 = 8t_2$

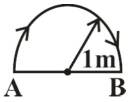
$= 8\,(4.08) = 32.65$

Total time to complete the journey

$t_1 + t_2 = 32.65 + 4.08$

$= 36.73$ sec

239. In 1s, a particle goes from point A to point B moving in a semi-circle of radius 1 m as shown in the figure. The magnitude of average velocity is



(a) 3.14 m/s (b) 2 m/s

(c) 1 m/s (d) 0

Assam CEE-2014

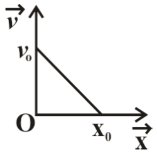
Ans. (b) :

Total displacement = shortest distance

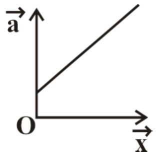
= diameter of semicircle = 2 m

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{2}{1} = 2 \text{ m/s}$$

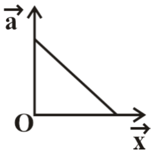
240. The figure below shows the variation of velocity v of a body with position x from the origin O. Which of the answer of the answer figures correctly represents the variation of acceleration α with position x ?



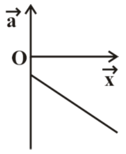
(a)



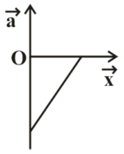
(b)



(c)



(d)



Assam CEE-2014

Ans. (d) : $V = mx + v_0 \qquad \ldots(i)$

m – slope of graph which is negative

v_0 – intercept of line which is positive

$$a = \frac{dv}{dt} = -m\left(\frac{dx}{dt}\right) + \frac{d}{dt}(v_0)$$

$a = -mv + 0$

From (i)

$a = -m\,(-mx + v_0)$

$a = m^2x - mv_0 \qquad \ldots(ii)$

Slope of (+ve) and Intercept is negative

241. A car starting from rest is accelerated at a constant rate α until it attains a speed ν. It is then retarded at a constant rate β until it comes to rest. The average speed of the car during its entire journey is

(a) 0 (b) $\frac{\nu}{2}$

(c) $\frac{\alpha\nu}{2\beta}$ (d) $\frac{\beta\nu}{2\alpha}$

Assam CEE-2014

@apna_pdf

Ans. (b) : Given that

Acceleration of the car = ∝

The average speed of the car

$$v_{avg} = \frac{s}{t} \quad \ldots(i)$$

When it start at rest u = 0 in time t_1

$$v = u + at$$

$$v = at_1 \quad \ldots(ii)$$

And distance travelled

$$s = ut + \frac{1}{2}at^2$$

$$s_1 = \frac{1}{2}at_1^2$$

When it comes to rate in time t_2

Rate of acceleration = Rate of deacceleration

When $t_1 = t_2$ $\quad s_2 = \frac{1}{2}at_2^2$

Since $t_1 = t_2$ $\quad s_2 = \frac{at_1^2}{2}$

From eq^n (i)

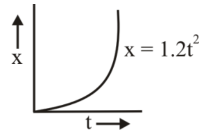
$$v_{avg} = \frac{s_1 + s_2}{t_1 + t_2} = \frac{\frac{at_1^2}{2} + \frac{at_1^2}{2}}{2t_1}$$

From eq^n (i)

$$\frac{2at_1^2}{2 \times 2t_1} = \frac{at_1}{2}$$

$$v_{avg} = \frac{v}{2}$$

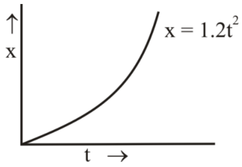
242. Figure given shows the distance-time graph of the motion of a car. It follows from the graph that the car is



(a) at rest
(b) in uniform motion
(c) in non-uniform acceleration
(d) uniformly accelerated

WB JEE 2009

Ans. (d) : The curve of x, t of car motion is parabolic–



$$x = 1.2t^2$$

Then, velocity $(v) = \frac{dx}{dt}$

$$v = \frac{d}{dt}(1.2t^2)$$

$$v = 2.4\,t$$

And,

$$\text{Acceleration } (a) = \frac{dv}{dt} = \frac{d}{dt}(2.4t)$$

$$a = 2.4 \quad \text{(constant)}$$

So, the motion of car is uniform acceleration.

243. The acceleration of a particle is increasing linearly with time t as bt. The particle starts from the origin with an initial velocity v_0. The distance travelled by the particle in time t will be

(a) $v_0t + \frac{1}{3}bt^2$
(b) $v_0t + \frac{1}{3}bt^3$
(c) $v_0t + \frac{1}{6}bt^3$
(d) $v_0t + \frac{1}{2}bt^2$

UP CPMT-2011

Ans. (c) : Given,

Acceleration a = bt

time = t

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{change in time}}$$

$$a = \frac{dv}{dt}$$

$$\frac{dv}{dt} = a = bt$$

$$\Rightarrow \quad \frac{dv}{dt} = bt$$

$$dv = bt\,dt$$

Now integrating this we will get

$$\int dv = \int bt\,dt$$

$$v = \frac{bt^2}{2} + C$$

At, $\quad t = 0,\ v = v_0$, thus $v_0 = C$

$$\therefore \quad v = \frac{bt^2}{2} + v_0$$

Now, $\quad v = \frac{\text{change is position}}{\text{change in time}} = \frac{ds}{dt}$

$$\Rightarrow \quad \frac{ds}{dt} = \frac{bt^2}{2} + v_0$$

$$\Rightarrow \quad ds = \left(\frac{bt^2}{2} + v_0\right)dt$$

Integrating above we get,

$$s = \frac{bt^3}{6} + v_0t + C$$

At $\quad t = 0,\ s = 0,\ C = 0$

i.e. $\quad s = \frac{bt^3}{6} + v_0t$

or $\quad s = v_0t + \frac{1}{6}bt^3$

@apna_pdf

244. A man is at a height of 100 m. He sees a car which makes an angle of $\frac{\pi}{6}$ with man's position. If the car moves to a point where angle is $\frac{\pi}{3}$, what is the distance moved by it ?

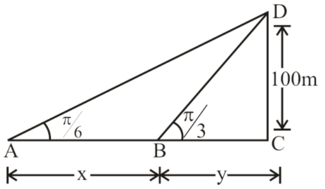
(a) $\left(\frac{100}{\sqrt{3}}\right)$m
(b) $\left(200\sqrt{3}\right)$m
(c) $\left(\frac{200}{\sqrt{3}}\right)$m
(d) $\left(\frac{150}{\sqrt{3}}\right)$m

UP CPMT-2003

Ans. (c) : A man is at a height of 100m. He sees a car which makes an angle of $\frac{\pi}{6}$ with man's position.

If the car moves to a point where angle is $\frac{\pi}{3}$

Let,



In ΔBCD

$$\tan\frac{\pi}{3} = \frac{DC}{BC}$$

$$\Rightarrow \quad \sqrt{3} = \frac{100}{y}$$

$$\Rightarrow \quad y = \frac{100}{\sqrt{3}}$$

Now,

In ΔACD

$$\tan\frac{\pi}{6} = \frac{DC}{AC}$$

$$\Rightarrow \quad \frac{1}{\sqrt{3}} = \frac{100}{AB+BC}$$

$$\Rightarrow \quad \frac{1}{\sqrt{3}} = \frac{100}{x+y}$$

$$\Rightarrow \quad x+y = 100\sqrt{3}$$

Put the value of y in above equation

$$x + \frac{100}{\sqrt{3}} = 100\sqrt{3}$$

$$x = 100\sqrt{3} - \frac{100}{\sqrt{3}}$$

$$x = \frac{100\times 3 - 100}{\sqrt{3}}$$

$$x = \frac{300-100}{\sqrt{3}}$$

$$x = \frac{200}{\sqrt{3}}\text{m}$$

245. The displacement of a particle moving in a straight line is given by the expression x = $At^3 + Bt^2 + Ct + D$ in meter, where t is in seconds and A, B, C and D are constants.
The ratio between the initial acceleration and initial velocity is

(a) $\frac{2C}{B}$
(b) $\frac{2B}{C}$
(c) 2C
(d) $\frac{C}{2B}$

TS EAMCET (Engg.)-2015

Ans. (b): Displacement of a particle moving in a straight line is given by

$$x = At^3+Bt^2+Ct+D$$

$$\text{Velocity } v = \frac{dx}{dt}$$

$$v = \frac{dx}{dt} = 3At^2 + 2Bt + C$$

Initial velocity is equal to $\frac{dx}{dt}$ at t = 0

$$\text{Initial velocity } v = \left(\frac{dx}{dt}\right) \text{at } t = 0 = C$$

$$\text{Acceleration } a = \frac{d^2x}{dt^2} = 6At + 2B$$

Initial acceleration a at t = 0

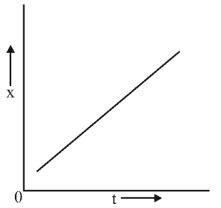
$$a = \left(\frac{d^2x}{dt^2}\right)_{t=0} = 2B$$

Ratio between the initial acceleration and initial

$$\text{Velocity is, } \frac{a}{v} = \frac{\left(\frac{d^2x}{dt^2}\right)_{t=0}}{\left(\frac{dx}{dt}\right)_{t=0}} = \frac{2B}{C}$$

$$\frac{a}{v} = \frac{2B}{C}$$

246. The position - time (x-t) graph for motion of a body is given below :



Which one among the following is depicted by the above graph ?

(a) Positive acceleration
(b) Negative acceleration
(c) Zero acceleration
(d) None of the above

NDA (II) 2011

Ans. (c): Given,
From the given (x–t) graph it is clear that velocity is constant.
Therefore, acceleration is zero

@apna_pdf

247. The displacement of a particle at time t is given by

$$\vec{x} = a\hat{i} + bt\hat{j} + \frac{c}{2}t^2\hat{k}$$

Where a, b and c are positive constants. Then the particle is

(a) accelerated along $\hat{k}$ direction

(b) decelerated along $\hat{k}$ direction

(c) decelerated along $\hat{j}$ direction

(d) accelerated along $\hat{j}$ direction

NDA (I) 2013

Ans. (a) : Given,

$$\vec{x} = a\hat{i} + bt\hat{j} + \frac{c}{2}t^2\hat{k}$$

$$\text{Velocity}\,(v_x) = \frac{dx}{dt}$$

$$v_x = 0$$

$$v_y = \frac{d(bt)}{dt}$$

$$v_y = b$$

And, $v_z = \frac{dz}{dt} = \frac{d}{dt}\left(\frac{c}{2}t^2\right)$

$$v_z = ct$$

Acceleration

$$a_x = \frac{dv_x}{dt} = 0$$

$$a_y = \frac{dv_y}{dt} = 0$$

$$a_z = \frac{dv_z}{dt} = c$$

Thus, the particle is acceleration along $\hat{k}$ direction.

248. If d denotes the distance covered by a car in time *t* and $\vec{S}$ denotes the displacement by the car during the same time, then:

(a) $d \le |\vec{S}|$

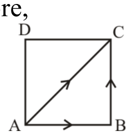
(b) $d = |\vec{S}|$

(c) $d \ge |\vec{S}|$

(d) $d < |\vec{S}|$

NDA (I) 2013

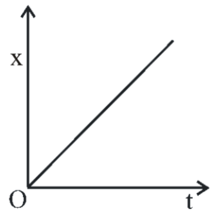
Ans. (c) : Given,
If d denotes the distance covered by a car in time t and $\vec{S}$ denotes the displacement by the car during the same that,
Displacement is the shortest distance covered by a body and distance is actual path covered by a moving object.
Therefore,



A–B–C distance
A–C displacement

$$d \ge |\vec{S}|$$

249.



The motion of a particle is given by a straight line in the graph given above drawn with displacement (x) and time (t). Which one among the following statements is correct?

(a) The velocity of the particle is uniform

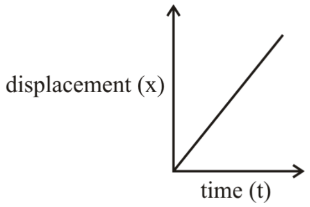
(b) The velocity of the particle is non-uniform

(c) The speed is uniform and the particle is moving on a circular path

(d) The speed is non-uniform and the particle is moving on a straight line path

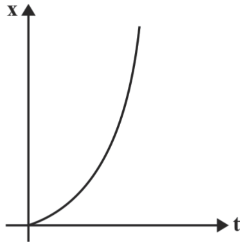
NDA (I) 2013

Ans. (a) :



See above graph.
The velocity of the particle is uniform

250.



The plot given above represents displacement 'x' of a particle with time 't'. The particle is

(a) moving with uniform velocity

(b) moving with acceleration

(c) moving with deceleration

(d) executing a periodic motion

NDA (II) 2013

Ans. (b): The above given graph is an upward parabola.

$$s = ut + \frac{1}{2}at^2$$

The above equation of motion is also a parabolic equation.
For the upward parabolic equation the t^2 term should be positive. Hence acceleration of the particle is positive. Thus the particle is moving with acceleration.

@apna_pdf

(b) Speed, Velocity and Acceleration

251. An object moves at a constant speed along a circular path in a horizontal plane with centre at the origin. When the object is at x = +2 m, its velocity is $-4\hat{j}$ m/s. The object's velocity (v) and acceleration (a) at x = –2 m will be

(a) $v = -4\hat{j}\,m/s, a = -8\hat{j}\,m/s^2$

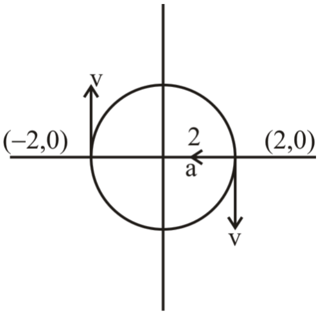
(b) $v = 4\hat{i}\,m/s, a = 8\hat{j}\,m/s^2$

(c) $v = 4\hat{j}\,m/s, a = 8\hat{i}\,m/s^2$

(d) $v = -4\hat{j}\,m/s, a = 8\hat{i}\,m/s^2$

JEE Main-29.01.2023, Shift-II

Ans. (c) : Given, Velocity at x = +2 m, v = $-4\,\hat{j}$ m/s



At (2, 0) ; $\vec{v} = -4\hat{j}$

At (–2,0) ; $\vec{v} = 4\hat{j}$

Centripetal acceleration magnitude,

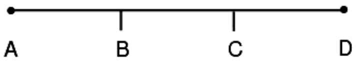
$$\vec{a} = \frac{v^2}{r}\hat{i} = \frac{4^2}{2}\hat{i} = 8\hat{i} \quad \Rightarrow \vec{a} = +8\hat{i}$$

Then,

Object velocity at x = –2 m, v = $4\hat{j}$ m/s

Object acceleration at x = –2 m, a = $8\hat{i}$ m/s^2

252. An object moves with speed v_1, v_2 and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where AB = BC and AD = 3AB, then average speed of the object will be:



(a) $\frac{(v_1 + v_2 + v_3)}{3}$

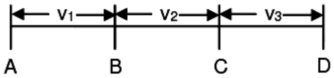
(b) $\frac{3v_1v_2v_3}{(v_1v_2 + v_2v_3 + v_3v_1)}$

(c) $\frac{(v_1v_2v_3)}{3v_1v_2v_3}$

(d) $\frac{v_1v_2v_3}{3(v_1v_2 + v_2v_3 + v_3v_1)}$

JEE Main-01.02.2023, Shift-I

Ans. (b) :



Let say AB = d meter

Then BC = d meter

AD = AB + BC + CD = 3AB

2AB + CD = 3AB (∵ AB = BC)

CD = AB

Hence, CD = d meter

$$\text{Average velocity} = \frac{3d}{\frac{d}{v_1} + \frac{d}{v_2} + \frac{d}{v_3}} = \frac{d}{d}\left(\frac{3}{\frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}}\right)$$

Average velocity =

$$\frac{3}{\left(\frac{v_2v_3 + v_1v_3 + v_1v_2}{v_1v_2v_3}\right)} = \frac{3v_1v_2v_3}{(v_1v_2 + v_2v_3 + v_1v_3)}$$

253. The distance travelled by a particle is related to time t as x = 4t^2. The velocity of the particle at t = 5s

(a) 8 ms^{-1} (b) 20 ms^{-1}

(c) 25 ms^{-1} (d) 40 ms^{-1}

JEE Main-25.01.2023, Shift-II

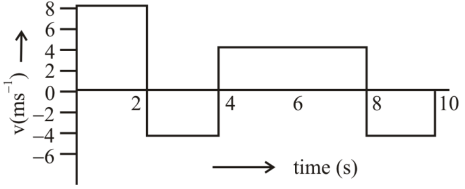
Ans. (d) : Given, x = 4t^2, t = 5s

We know,

$$v = \frac{dx}{dt} = \frac{d}{dt}(4t^2) = 8t$$

At, t = 5 s v = 8 × 5 = 40 m/s

254. The velocity time graph of a body moving in a straight line is shown in figure.



The ratio of displacement to distance travelled by the body in time 0 to 10s is:

(a) 1:2 (b) 1:4

(c) 1:3 (d) 1:1

JEE Main-24.01.2023, Shift-II

Ans. (c): We know,

Area under the v-t diagram give the displacement–

Displacement = Summation of all the area

= $A_1 + (-A_2) + (A_3) + (-A_4)$

= 16 – 8 + 16 – 8

= 16 m

Distance = 16+8+16+8 = 48 m

Displacement : Distance = 16 : 48 = 1 : 3

255. A vehicle travels 4 km with speed of 3 km/h and another 4 km with speed of 5 km/h, then its average speed is

(a) 3.75 km/h (b) 4.25 km/h

(c) 3.50 km/h (d) 4.00 km/h

JEE Main-30.01.2023, Shift-II

@apna_pdf

Ans. (a) : Given, $d_1 = 4$ km, $v_1 = 3$ km/h and $d_2 = 4$ km, $v_2 = 5$ km/h

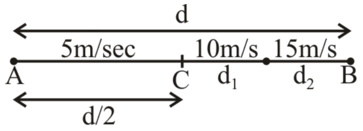
$$\text{Average speed} = \frac{2v_1v_2}{v_1+v_2}$$

$$= \frac{2\times3\times5}{3+5} = \frac{15}{4}\text{km/hr} = 3.75\text{km/h}$$

256. A horse rider covers half the distance with 5 m/s speed. The remaining part of the distance was travelled with speed 10 m/s for half the time and with speed 15 m/s for other half of the time. The mean speed of the rider averaged over the whole time of motion is $\frac{x}{7}$ m/s. The value of x is _____.

JEE Main-30.01.2023, Shift-I

Ans. (50) :



We know, average speed $= \frac{\text{Total distance}}{\text{Total time}}$

Time for distance, AC

$$t_1 = \frac{d}{2\times5} = \frac{d}{10}\text{sec.}$$

Time for distance CB, 2t (t for 10 m/s and t for 15 m/sec.)

$$\frac{d}{2} = 10t + 15t$$

$$\frac{d}{2} = 25t$$

$$2t = \frac{d}{25}$$

Then,

$$\text{Average speed (v)} = \frac{d}{\frac{d}{10}+\frac{d}{25}}$$

$$= \frac{d}{\frac{d(5+2)}{50}}$$

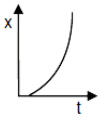
$$v = \frac{50}{7}$$

Hence, x = 50

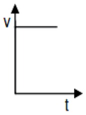
257. Match Column-I with Column-II:

Column-I: (x-t graphs)Column-II: (v-t graphs)

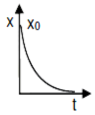
(a)



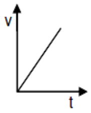
(i)



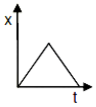
(b)



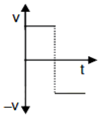
(ii)



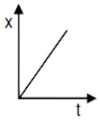
(c)



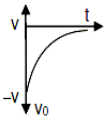
(iii)



(d)



(iv)



Choose the correct answer from the options given below:

(a) A-I, B-III, C-IV, D-II

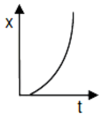
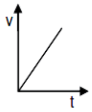
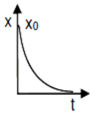
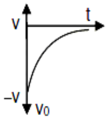
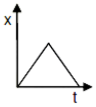
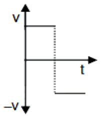
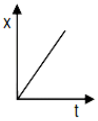
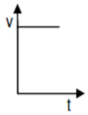
(b) A-II, B-IV, C-III, D-I

(c) A-II, B-III, C-IV, D-I

(d) A-I, B-II, C-III, D-IV

JEE Main-30.01.2023, Shift-I

Ans. (b) :

x-t graph	**v-t graph**
	
	
	
	

258. A car travels a distance of 'x' with speed v_1 and then same distance 'x' with speed v_2 in the same direction. The average speed of the car is.

(a) $\frac{v_1v_2}{2(v_1+v_2)}$

(b) $\frac{2x}{v_1+v_2}$

(c) $\frac{2v_1v_2}{v_1+v_2}$

(d) $\frac{v_1+v_2}{2}$

JEE Main-25.01.2023, Shift-I

Ans. (c) : We know,

$$\text{Average speed} = \frac{\text{Total distance}}{\text{total time}}$$

When car travels a distance 'x' with velocity v_1

Then, time $(t_1) = \frac{x}{v_1}$

And same distance x with velocity v_2

Then, time $(t_2) = \frac{x}{v_2}$

$\therefore$ Total time $= \frac{x}{v_1} + \frac{x}{v_2}$

@apna_pdf

$$\because \quad \text{Average speed} = \frac{x+x}{\frac{x}{v_1}+\frac{x}{v_2}} = \frac{2x}{x\left(\frac{v_1+v_2}{v_1v_2}\right)}$$

$$\text{Average speed} = \frac{2v_1v_2}{v_1+v_2}$$

259. The position x of a particle varies with time (t) as $x = A\,t^2 - B\,t^3$. The acceleration at time t of the particle will be equal to zero. What is the value of t?

(a) $\frac{2A}{3B}$ (b) $\frac{A}{B}$

(c) $\frac{A}{3B}$ (d) zero

BITSAT-2010, 2006
CBSE PMT-1997
DPMT-2000
BHU-1999
KCET-2000

Ans. (c) : Given that,

$$x = At^2 - Bt^3$$

$$(v) = \frac{dx}{dt} = 2At - 3Bt^2$$

$$\text{Acceleration (a)} = \frac{d^2x}{dt^2} = \frac{d}{dt}\left(2At - 3Bt^2\right)$$

$$a = 2A - 6Bt$$

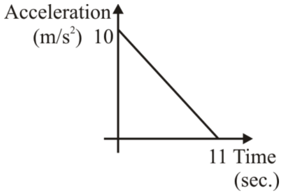
Put a = 0

$$2A = 6Bt$$

$$t = \frac{2A}{6B}$$

$$t = \frac{A}{3B}$$

260. A body starts from rest at time t = 0, the acceleration time graph is shown in the figure. The maximum velocity attained by the body will be



(a) 110m/s (b) 55m/s

(c) 650m/s (d) 550m/s

CG PET-22.05.2022
BITSAT-2016
AIIMS-2014

Ans. (b) : Area under the acceleration - time graph determines the change in velocity i.e.

$$a = \frac{dv}{dt}$$

$$dv = \int a dt$$

Area under the curve will gives us change in velocity

$$v_i = 0,\ v_f = v_{max}$$

$$\Delta v = \text{area under the curve} = \frac{1}{2} \times 10 \times 11 = 55$$

$$\Delta v = v_f - v_i$$

$$v_f = 55 \text{ m/s}$$

$$v_f = v_{max} = 55 \text{ m/s}$$

261. A particle moving along X-axis has acceleration f at time t given by $f = f_0\left(1 - \frac{t}{T}\right)$, where f_0 and T are constants. The particle at t = 0 has zero velocity. In the time interval between t = 0 and the instant when f = 0, the particle's velocity is

(a) $\frac{1}{2}f_0T^2$ (b) f_0T^2

(c) $\frac{1}{2}f_0T$ (d) f_0T

TS-EAMCET-11.09.2020, Shift-1
BITSAT-2017
AIPMT-2007
UPSEE-2014

Ans. (c) : Acceleration of the particle is given as –

$$f = f_0\left(1 - \frac{t}{T}\right) \quad \text{...(i)}$$

∴ Velocity of particle is given as,

$$v = \int f\ dt = \int f_0\left(1 - \frac{t}{T}\right)dt = f_0\left(t - \frac{t^2}{2T}\right) + c \quad \text{...(ii)}$$

Given that, at t = 0, v = 0

Hence, from Eq. (i), we get

$$0 = f_0(0-0) + c \Rightarrow c = 0$$

∴ From Eq. (ii), we have

$$v = f_0\left(t - \frac{t^2}{2T}\right) \quad \text{...(iii)}$$

Suppose, acceleration of the particle becomes zero at time $t = t_1$.

Hence, from Eq. (i),

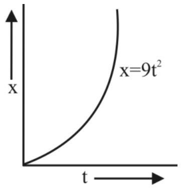
$$0 = f_0\left(1 - \frac{t_1}{T}\right) \Rightarrow 1 - \frac{t_1}{T} = 0 \Rightarrow t_1 = T$$

Hence, velocity of particle at $t = t_1 = T$,
from Eq. (iii),

$$v = f_0\left(t_1 - \frac{t_1^2}{2T}\right)$$

$$v = f_0\left(T - \frac{T^2}{2T}\right) = f_0\left(T - \frac{T}{2}\right) = \frac{1}{2}f_0T$$

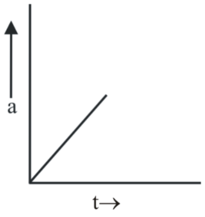
262. The displacement-time graph of a particle moving along a straight line is shown in the figure.



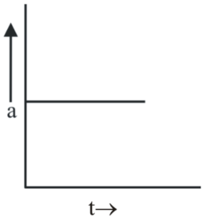
@apna_pdf

The acceleration- time graph of this particle is

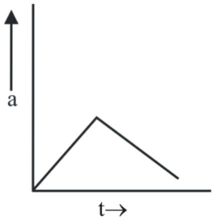
(a)



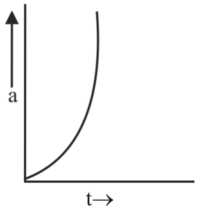
(b)



(c)



(d)



Manipal UGET-2020
CG PET- 2014

Ans. (b) : Given that, $x = 9t^2$

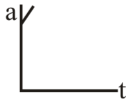
$$\therefore \quad v=\frac{dx}{dt}=\frac{d}{dt}\left(9t^2\right)=9\frac{d}{dt}\left(t^2\right)=18t$$

And $$a=\frac{d^2x}{dt^2}=\frac{dv}{dt}=\frac{d}{dt}(18t)=18$$

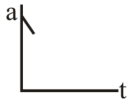
As acceleration is constant, the graph between acceleration and time is a line parallel to time axis.

263. A body moves with uniform acceleration, then which of the following graph is correct?

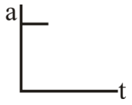
(a)



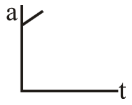
(b)



(c)



(d)



BITSAT-2012
UP CPMT-2007

Ans. (c) : A body moves with uniform (constant) acceleration, then acceleration is same at all interval of time. So the slope of the acceleration-time graph is zero, i.e. graph will be parallel to the time axis (x-axis).

For uniform acceleration, the velocity will increase by equal amount for equal intervals of time. The velocity time graph of uniformly accelerated motion is a straight line inclined to time axis.

264. A car moves from X to Y with a uniform speed v_u returns to Y with a uniform speed v_d. The average speed for this round trip is

(a) $\frac{2v_dv_u}{v_d+v_u}$

(b) $\sqrt{v_uv_d}$

(c) $\frac{v_dv_u}{v_d+v_u}$

(d) $\frac{v_u+v_d}{2}$

UPSEE - 2007
AIPMT - 2007

Ans. (a) : We know that

$$\text{Average speed}=\frac{\text{Total distance travelled}}{\text{Total time taken}}$$

Assume t_1 and t_2 are the times taken by car to go from x to y and then from y to x respectively

$$\therefore \quad t_1+t_2=\frac{xy}{v_u}+\frac{xy}{v_d}$$

$$t_1+t_2=xy\left(\frac{v_u+v_d}{v_uv_d}\right)$$

$\therefore$ Total distance = xy + xy = 2xy

$$\text{Hence, average speed}=\frac{\text{Total distance}}{\text{Total time}}$$

$$v_{avg}=\frac{2xy}{xy\left(\frac{v_u+v_d}{v_uv_d}\right)}$$

$$\boxed{v_{avg}=\frac{2v_u.v_d}{v_u+v_d}}$$

265. A body of mass m moving along a straight line covers half the distance with a speed of 2 ms^{-1}. The remaining half of the distance is covered in two equal time intervals with a speed of 3 ms^{-1} and 5 ms^{-1} respectively. The average speed of the particle for the entire journey is

(a) $\frac{3}{8}\text{ms}^{-1}$

(b) $\frac{8}{3}\text{ms}^{-1}$

(c) $\frac{4}{3}\text{ms}^{-1}$

(d) $\frac{16}{3}\text{ms}^{-1}$

Manipal UGET-2009
Karnataka CET-2009

Ans. (b) : Suppose that total distance travelled by the body is 2s.

Given that s distance is travelled by 2m/s.

Time taken by the body to travel first half distance

$$t_1=\frac{s}{2}$$

And let t_2 be the time taken by the body to cover remaining half distance 3m/s and 5m/s

So, distance (s) = $3t_2 + 5t_2 = 8t_2$

$$t_2=\frac{s}{8}$$

$$V_{avg}=\frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$=\frac{2s}{t_1+2t_2}$$

$$=\frac{2s}{\frac{s}{2}+2\frac{s}{8}}=\frac{2s}{\frac{s}{2}+\frac{s}{4}}$$

$$V_{avg}=\frac{8}{3}\text{m/s}$$

@apna_pdf

266. **A body starts from rest with an acceleration a_1. After two seconds another body B starts from rest with an acceleration a_2. If they travel equal distances in fifth second after the starts of A, the ratio $a_1 : a_2$ will be equal to:**

(a) 9 : 5 (b) 5 : 7
(c) 5 : 9 (d) 7 : 9

AIIMS-26.05.2019(M) Shift-1
AIIMS-2001

Ans. (c): Given that,
Initial velocity u = 0
Distance covered in n^th second after starting from rest -

$$s_n = u + \frac{a}{2}(2n - 1)$$

For A: n = 5

$$S_5 = \frac{a_1}{2}(2 \times 5 - 1) = \frac{9}{2}a_1 \qquad (\because u = 0)$$

For B: n = 3

$$S_3 = \frac{a_2}{2}(2 \times 3 - 1) = \frac{5}{2}a_2$$

According to question, $S_5 = S_3$

$$\frac{9}{2}a_1 = \frac{5}{2}a_2$$

$a_1 : a_2 = 5:9$

267. **A man drives a car from station B towards station A at speed 60 km/h. A car leaves station A for station B every 10 min. The distance between A and B is 60 km. The car travels at the speed of 60 km/h. A man drives a car from B towards A at speed of 60 km/h. If the starts at the moment when first car leaves the station B, then how many cars would be meet on the route?**

(a) 4 (b) 7
(c) 9 (d) 12

BITSAT-2019
BITSAT-2015

Ans. (b) : Given that,
Speed of every car = 60 km/h
We know
d = speed × time

$$d = 60 \times \frac{10}{60} = 10\,\text{km}$$

Total distance travelled by both the car = 60km.
Man meets the first car after time t_1

$$t_1 = \frac{\text{Total distance}}{\text{Total speed}} = \frac{60}{60+60} = \frac{1}{2}\text{h}$$

When he will meet the next car after time t_2

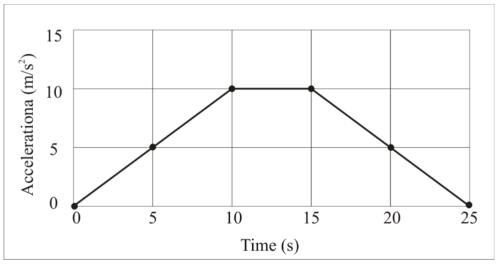
$$t_2 = \frac{10}{60+60} = \frac{1}{12}\text{h}$$

Number of cars he will meet in remaining half hour

$$n = \frac{1/2}{1/12} = 6$$

∴ Total no. of cars he will meet on route = 6 + 1 = 7.

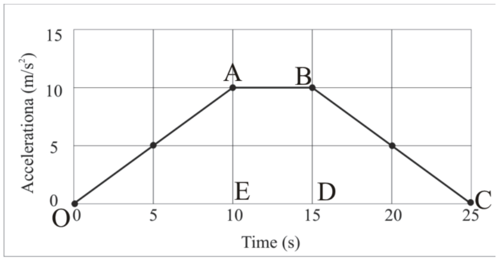
268. **The following plot gives the variation of acceleration (m/s^2) with time (s) for an object that started from rest at time t = 0 s. The velocity at time t= 15 s (V_{15}) and at 25 s (V_{25}), respectively are**



(a) V_{15} = 50 m/s and V_{25} = 0 m/s
(b) V_{15} = 100 m/s and V_{25} = 150 m/s
(c) V_{15} = 50 m/s and V_{25} = 25 m/s
(d) V_{15} = 100 m/s and V_{25} = 25 m/s
(e) V_{15} = 75 m/s and V_{25} = 50 m/s

Kerala CEE-2019
TS EAMCET (Engg.)-2015

Ans. (b) :



The velocity at time , t =15 sec.
V_{15} = Area of (ΔOAE+ ABDE)

$$= \frac{1}{2} \times 10 \times 10 + 10 \times (15 - 10)$$

V_{15} = 100 m/s
Velocity at time, t= 25 sec.
V_{25} = Area of (ΔOAE+ ABDE+ΔBCD)
=

$$\frac{1}{2} \times 10 \times 10 + 10 \times (15 - 10) + \frac{1}{2} \times 10 \times (25 - 15)$$

V_{25} = 150 m/s

269. **Which one of the following statements about speed and velocity is correct?**

(a) Speed and velocity both are vector quantities
(b) Speed and velocity both are scalar quantities.
(c) Speed is vector quantity and velocity is scalar quantity.
(d) Speed is scalar quantity and velocity is vector quantity.

NDA-04.09.2022

Ans. (d): Speed is scalar quantity–
It is the rate of change in the distance travelled by an objects, while velocity is a vector quantity– It is the speed of on object in a particular direction.

@apna_pdf

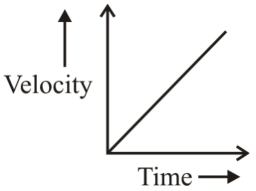
270. What is the nature of velocity-time graph for a car moving with uniform acceleration?

(a) Parabola (b) Logarithmic

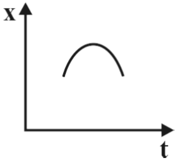
(c) Straight line (d) Exponential

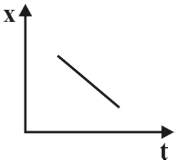
NDA-04.09.2022

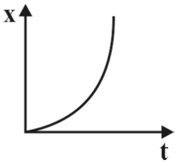
Ans. (c): The velocity – time graph for uniform accelerated motion is a straight line.

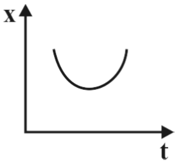


271. The correct position (x) – time (t) graph for a particle moving with negative acceleration is–

(a)


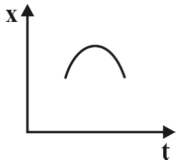
(b)


(c)


(d)


AP EAMCET-08.07.2022, Shift-I

Ans. (a) : The position (x) of verses time (t) graph for a particle moving with a negative accelerations is –



272. Two buses of length 60 feet and 40 feet are moving parallel towards each other at a speed 15 feet/s and 10 feet/s respectively. Time taken to pass each other is

(a) $\frac{4}{5}$s (b) 4 s

(c) 8 s (d) 20 s

AP EAMCET-12.07.2022, Shift-I

Ans. (b) : Total distance = 60 + 40 = 100 feet

Relative speed of buses = 15+10 = 25 feet/sec

Time taken to pass

$$\therefore \quad \text{Required time} = \frac{\text{Total distance}}{\text{Releative speed}}$$

$$= \frac{100}{25} = 4\,\text{sec}$$

273. A car is moving along a straight line is brought to a stop within a distance of 200 m and in time 10s. The initial speed of the car is–

(a) 25 m s^{-1} (b) 50 m s^{-1}

(c) 75 m s^{-1} (d) 40 m s^{-1}

AP EAMCET-07.07.2022, Shift-II

Ans. (d) : Given,

s = 200m, t= 10 sec, v = 0 m/s

Let initial velocity of the car = u m/sec

$\because$ v = u+at

0 = u+a×10

u = –10a ……(i)

$\because$ s = ut+1/2 at^2

$$200 = u \times 10 + \frac{1}{2} a \times (10)^2$$

$$200 = (-10a) \times 10 + \frac{1}{2} a \times 100 \qquad (\because u = -10a)$$

200 = –100 a +50 a

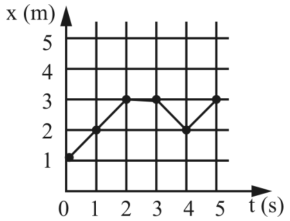
200 = –50 a

a = – 4m/sec^2

Put a = –4 m/s^2 in equation (i), we get

u = –10×–4 = 40 m/s

274. A particle moves along a straight line along the X-axis. Its position (X) versus time (t) graph is shown in the figure [x in meters and t in seconds]. It's average speed during this motion is



(a) 0.4 ms^{-1} (b) 1.0 ms^{-1}

(c) 0.8 ms^{-1} (d) 0.6 ms^{-1}

AP EAMCET-06.07.2022, Shift-I

Ans. (c): Total traveled distance

= |1-2|+|2–3|+|3–3|+|3–2|+|2–3|

= 1+1+0+1+1 = 4

Total time = 5 sec

$$\text{Average speed} = \frac{\text{Total distance}}{\text{total time}}$$

$$= \frac{4}{5} = 0.8\,\text{m/sec}$$

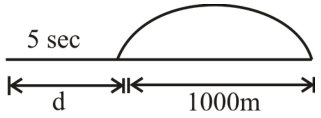
275. A person is running with an uniform velocity towards a flyover. He takes 5 s to reach the flyover from a reference point and takes 50 s to cross the flyover from the same reference point. If the length of the flyover is 1000 m then his velocity in nearly

(a) 83.1 kmph (b) 80.0 kmph

(c) 75.4 kmph (d) 85.2 kmph

AP EAPCET-12.07.2022, Shift-II

Ans. (b) :



$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

@apna_pdf

$$v=\frac{d}{5}$$

$$d=5v$$

$$v=\frac{d+1000}{50}$$

$$v=\frac{5v+1000}{50}$$

$$50v=5v+1000$$

$$v=\frac{1000}{45}$$

$$v=22.22\times\frac{18}{5}\text{ kmph}$$

$$v=80\text{ kmph}$$

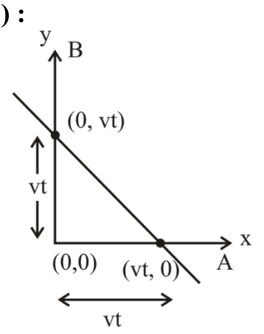
276. Two particles A and B are moving along positive x-and positive y-axes respectively with the same speed v m s^{-1}. At t = 0, they both pass through the origin. The equation of the straight line joining A and B at time t is

(a) $y(t)=x(t)+vt$ (b) $y(t)=-x(t)+vt$

(c) $y(t)=+x(t)$ (d) $y(t)=-x(t)$

AP EAPCET-12.07.2022, Shift-II

Ans. (b) :



Both particle are moving with speed v ms^{-1}.

$\because$ Distance = speed×time

Then, at time t sec

Distance traveled by A on X axis = vt

Distance traveled by B on Y axis = vt

$\because$ Equation of straight line passing through the points (x_1, y_1) and (x_2, y_2)

$$y-y_1=\frac{y_2-y_1}{x_2-x_1}(x-x_1)$$

$$y-0=\frac{vt-0}{0-vt}(x-vt)$$

$$y=-x+vt$$

or

$$y(t)=-x(t)+vt$$

277. A truck carrying sand having a total mass of 1600 kg is moving with a uniform velocity of 15 ms^{-1}. Sand is dropped into it at a rate of 24 kg min^{-1}. The force needed to keep the truck moving with uniform velocity is

(a) 6 N (b) 1.6 N

(c) 40 N (d) 4 N

AP EAPCET-12.07.2022, Shift-II

Ans. (a) : Given that –

Total mass = 1600 kg

Velocity = 15 m/sec

Dropped sand permit = 24 kg/min $=\frac{24}{60}\text{kg/sec}=\frac{2}{5}$

$$\therefore\quad f=\frac{dp}{dt}$$

$$\Rightarrow f=\frac{d(mv)}{dt}\Rightarrow f=\frac{v.dm}{dt}$$

$$=15\times\frac{2}{5}\text{kg}\frac{m}{\sec^2}$$

$$=3\times2\text{ N}=6\text{ N}$$

278. A passenger saw a bus standing 10 meters ahead of him. The bus started moving with a constant acceleration 5 ms^{-2} away from him. To catch the bus the passenger ran at constant speed towards the bus. The minimum speed of the passenger to catch the bus is

(a) $10\sqrt{2}\text{ms}^{-1}$ (b) $5\sqrt{2}\text{ms}^{-1}$

(c) 10ms^{-1} (d) 50ms^{-1}

AP EAMCET-11.07.2022, Shift-II

Ans. (c) : Given,

Acceleration of bus (a) = 5 ms^{-2}

Initial speed of bus (u) = 0 m/s

Let the person catch the bus at time t sec with speed v m/sec.

$$\because\quad s=ut+\frac{1}{2}at^2$$

$$s=0\times t+\frac{1}{2}\times5\times t^2\Rightarrow s=\frac{5}{2}t^2$$

As the person was at 10 m distance from bus.

So, Distance covered by person = 10 + s

$$=10+\frac{5}{2}t^2$$

$\because$ Distance = speed×time

$$10+\frac{5}{2}t^2=vt$$

$$5t^2-2vt+20=0$$

For real root of quadratic equation

$$b^2-4ac\ge0$$

i.e. $(-2v)^2-4\times5\times20\ge0$

$$4v^2\ge400$$

$$v^2\ge100$$

$$v\ge10$$

So, $V_{min}=10$ m/sec

279. A car travels with a speed of 40 km h^{-1}. Rain drops are falling at a constant speed vertically. The traces of the rain on the side windows of the car make an angle of 30° with the vertical. The magnitude of the velocity of the rain with respect to the car is

@apna_pdf

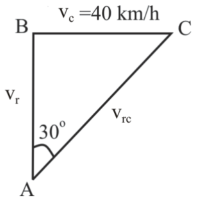
(a) $40\sqrt{3}\,\text{km h}^{-1}$ (b) $\dfrac{40}{\sqrt{3}}\text{km h}^{-1}$

(c) $80\,\text{km h}^{-1}$ (d) $\dfrac{80}{\sqrt{3}}\text{km h}^{-1}$

AP EAMCET-04.07.2022, Shift-I

Ans. (c) : Velocity of car (v_c) = 40 km/h

Let velocity of rain is v_r and velocity of rain with respect to car is v_{rc}.



In ΔABC

$$\tan 30^\circ = \frac{v_c}{v_r} \Rightarrow \frac{1}{\sqrt{3}} = \frac{40}{v_r}$$

$$v_r = 40\sqrt{3}\,\text{km/h}$$

Now,

$$v_{rc} = \sqrt{v_r^2 + v_c^2}$$

$$= \sqrt{\left(40\sqrt{3}\right)^2 + (40)^2} = 40\sqrt{3+1} \Rightarrow 80\,\text{km/h}$$

280. A student is at a distance 16 m from a bus when the bus begins to move with a constant acceleration of 9 m s^{-2}. The minimum velocity with which the student should run towards the bus so as the catch it is $\alpha\sqrt{2}$ ms^{-1}. The value of α is

(a) 10 (b) 12

(c) 15 (d) 20

AP EAMCET-05.07.2022, Shift-I

Ans. (b): Given,

Initial velocity of bus (u) = 0 m/s

Distance between student and bus = 16 m

Acceleration (a) = 9 ms^{-2}

Let the boy catch the bus at time t.

$$\because \quad s = ut + \frac{1}{2}\times at^2$$

$$s = 0\times t + \frac{1}{2}9t^2$$

$$s = \frac{9}{2}t^2 \qquad \text{...(i)}$$

For the boy distance = (s +16)m

$$s' = \left(\frac{9}{2}t^2 + 16\right)\text{m}$$

Let the velocity of the boy is v_b m/s

∵ Distance = speed × time

$$\frac{9}{2}t^2 + 16 = v_b \times t$$

$$9t^2 - 2v_b t + 32 = 0$$

From real root of quadratic equation

$$b^2 - 4ac \geq 0$$

$$(-2v_b)^2 - 4 \times 9 \times 32 \geq 0$$

$$4v_b^2 \geq 4\times 9\times 32$$

$$v_b \geq 12\sqrt{2}$$

Thus, minimum velocity (v_b) = 12 m/s

Therefore,

$$\alpha\sqrt{2} = 12\sqrt{2}$$

$$\alpha = 12$$

281. Same force acts on two bodies of different masses 3kg and 5kg initially at rest. The ratio of times required to acquire same final velocity is-

(a) 5:3 (b) 25:9

(c) 9:25 (d) 3:5

CG PET-22.05.2022

Ans. (d) :

Given $m_1 = 3\text{kg} \quad m_2 = 5\text{kg}$

Initial velocity u = 0

Final velocity = v

$$v = u + at$$

$$v = at$$

$$v = \frac{f}{m}t \qquad [\because f = ma]$$

Let velocities be v_1 , v_2 = v

$$\frac{v_1}{v_2} = \frac{\dfrac{t_1}{m_1}}{\dfrac{t_2}{m_2}}$$

$$\frac{v}{v} = \frac{t_1}{3}\times\frac{5}{t_2}$$

$$1 = \frac{t_1}{t_2}\times\frac{5}{3}$$

$$\frac{t_1}{t_2} = \frac{3}{5}$$

$$t_1 : t_2 = 3 : 5$$

282. Weight of a body of mass m in its free fall above the surface of the earth is

(a) mg (b) $\sqrt{mg}$

(c) infinity (d) $m\sqrt{g}$

(e) zero

Kerala CEE 04.07.2022

Ans. (e) : The weight of free fall of any body will always be zero. Because there no reaction force applied on the free fall body so that weight will be zero.

283. A cyclist starting from rest moves with uniform acceleration and covers 120 m in 10s. Then his acceleration in ms^{-2} is

(a) 5 (b) 1.5

(c) 2.4 (d) 3

(e) 4.8

Kerala CEE 04.07.2022

@apna_pdf

Ans. (c) : Given, Initial Velocity (u) = 0
Total Distance covered (s) = 120m
Total time (t) = 10s
Acceleration (a) = ?
From Newton's Law of motion,

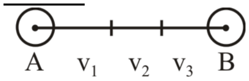
$$s = ut + \frac{1}{2}at^2$$

$$120 = 0 \times 10 + \frac{1}{2} \times a \times 10^2$$

$$120 = 50\ a$$

$$a = \frac{120}{50} = 2.4\ m/sec^2$$

284. A car covers AB distance with first one–third at velocity v_1 ms^{-1}, second one-third at v_2 ms^{-1} and last one–third at v_3 ms^{-1}. If $v_3 = 3v_1$, $v_2 = 2v_1$ and $v_1 = 11ms^{-1}$ then the average velocity of the car is ______ ms^{-1}.



JEE Main-28.06.2022, Shift-II

Ans. (18) : Suppose the displacement is *l*.
We know that–

$$v = \frac{\text{Displacement}}{\text{time}}$$

$$= \frac{l}{\left(\frac{l}{v_1} + \frac{l}{v_2} + \frac{l}{v_3}\right) \cdot \frac{1}{3}}$$

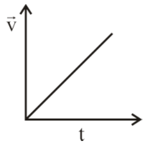
$$= \frac{3}{\frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}}$$

$$= \frac{3}{\frac{1}{11} + \frac{1}{22} + \frac{1}{33}}$$

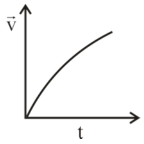
$$v = 18\ m/s$$

285. When a body starts from rest and moves with a constant acceleration, the velocity-time graph for its motion is

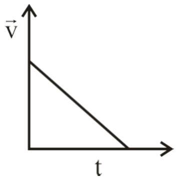
(a)



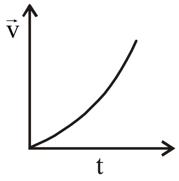
(b)



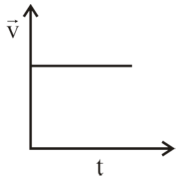
(c)



(d)

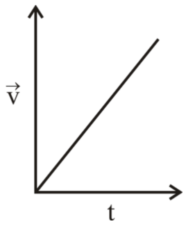


(e)



Kerala CEE 2021

Ans. (a) :



When a body start rest and moves with a constant acceleration.
Since velocity is increasing with time uniformly.

286. The stopping distance of a moving vehicle is proportional to the

(a) initial velocity
(b) cube of the initial velocity
(c) square of the initial velocity
(d) cube root of the initial velocity
(e) square root of the initial velocity

Kerala CEE 2021

Ans. (c): The stopping distance of a moving vehicle is propotional to the square of the initial velocity.
Let,

Initial velocity = u
Final velocity (v) = 0

Using third equation of motion

$$v^2 = u^2 + 2as$$

$$(0)^2 = u^2 + 2as$$

$$-u^2 = -2as \qquad [\because a = \text{acceleration}$$

$$s = \frac{u^2}{2a} \qquad s = \text{stopping, side distance}]$$

$$s \propto u^2$$

287. The displacement of a particle starting from rest a t = 0 is given by $s = 9t^2 - 2t^3$. The time in seconds at which the particle will attain zero velocity is——

(a) 8s	(b) 6s
(c) 4s	(d) 3s

AP EAMCET-20.08.2021, Shift-I

Ans. (d) : Given data, $s = 9t^2 - 2t^3$

$$\therefore \quad v = \frac{ds}{dt} = 18t - 6t^2$$

$$v = 18\ t - 6t^2$$

$$0 = 6t\ (3 - t) \qquad \{\because v = 0\}$$

$$t = 0 \text{ or } 3sec$$

So, the particle will attain zero velocity at the time of 3 seconds.
So, option (d) is correct.

288. The slope of velocity - time graph for motion with uniform velocity is equal to:

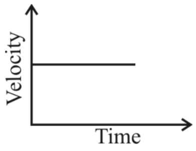
(a) Initial velocity	(b) Final velocity
(c) Zero	(d) Constant velocity

AP EAMCET-24.08.2021, Shift-II

@apna_pdf

Ans. (c): When velocity is uniform, velocity time graph is straight line parallel to the time axis.

So, the slope is zero.



For constant velocity acceleration, a = 0

$\because a = \frac{dv}{dt}$

$\because \frac{dv}{dt} = 0$

So, option (c) is correct

289. The displacement of a particle moving along x-axis is given by $x = 8t^2 + 18t$. The average acceleration during the interval $t_1 = 2$ and $t_2 = 4$s is ____

(a) 18 $m.s^{-2}$ (b) 32 $m.s^{-2}$

(c) 20 $m.s^{-2}$ (d) 16 $m.s^{-2}$

AP EAMCET-03.09.2021, Shift-II

Ans. (d) : According to equation,

The displacement of the particle is given by,

$$x = 8t^2 + 18t$$

$$\therefore v = \frac{dx}{dt} = 16t + 18$$

$$v = 16t + 18$$

at $t_1 = 2$ sec $\Rightarrow v_1 = 16\times2 + 18 = 32 + 18 = 50$ m/s

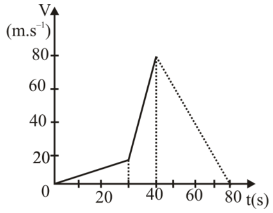
at $t_2 = 4$ sec $\Rightarrow v_2 = 16 \times 4 + 18 = 64 + 18 = 82$ m/s

average acceleration, $a = \frac{v_2 - v_1}{t} = \frac{82-50}{2} = \frac{32}{2} = 16$

$\boxed{a = 16\ ms^{-2}}$

So, option (d) is correct

290. The velocity-time graph of a moving object is shown in the figure. Find its maximum acceleration?

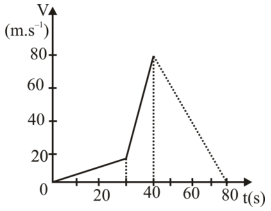


(a) 3 m. s^{-2} (b) 6 m. s^{-2}

(c) 4 $m.s^{-2}$ (d) 5 m. s^{-2}

AP EAMCET-07.09.2021, Shift-I

Ans. (b)



Acceleration in the 1st part.

$$a_1 = \frac{20-0}{30-0} = 0.66\, m/s^2$$

Acceleration in the 2nd part.

$$a_2 = \frac{80-20}{40-30} = 6\, m/s^2$$

Acceleration in the 3rd part.

$$a_3 = \frac{0-80}{80-40} = -2 m/s^2$$

Max. acceleration is $6 m/s^2$

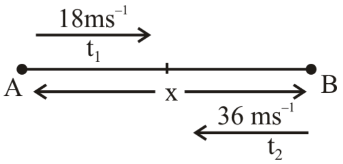
291. A train travels from city-A to city-B with a constant speed of 18 $m.s^{-1}$ and returns back to city-A with a constant speed of 36 $m.s^{-1}$. Find its average speed during the journey.

(a) $\frac{72}{5} m.s^{-1}$ (b) $\frac{36}{3} m.s^{-1}$

(c) $\frac{72}{3} m.s^{-1}$ (d) $\frac{36}{5} m.s^{-1}$

AP EAMCET-24.08.2021, Shift-I

Ans. (c) : Let the distance between the two cities A and B is x meter.



Time taken by the train to travel from A to B

$$\frac{x}{18} = t_1 \quad \left(\begin{array}{l}\because \text{Time} = \frac{\text{Distance}}{\text{Speed}} \\ \text{A to B speed} = 18ms^{-1}\end{array}\right)$$

Time taken to come back from B to A.

$$\frac{x}{36} = t_2 \text{ (B to A speed } = 36\ ms^{-1})$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{x+x}{t_1+t_2}$$

$$= \frac{2x}{\frac{x}{18}+\frac{x}{36}} = \frac{2x\times36}{2x+x}$$

$$= \frac{2x\times36}{3x} = \frac{72x}{3x} m/sec$$

$$\text{Average speed} = \frac{72}{3} ms^{-1}$$

292. An object travelling at a speed of 36 kmph comes to rest in a distance of 200 m after the brakes were applied. The retardation produced by the brakes is ——

(a) 0.25 $m.s^{-2}$ (b) 0.20 $m.s^{-2}$

(c) 0.15 $m.s^{-2}$ (d) 0.10 $m.s^{-2}$

AP EAMCET-19.08.2021, Shift-II

@apna_pdf

Ans. (a) : Given that,

$$u = 36\text{ km/h} = 36\times\frac{5}{18} = 10\text{ms}^{-1}$$

s = 200 m

v = 0

a = ?

By third law of Motion–

$v^2 - u^2 = 2as$

$0^2 - (10)^2 = 2 \times a \times 200$

$-100 = 400a$

$$a = \frac{-100}{400} = -0.25$$

Retardation is = 0.25 ms^{-2}

293. When a particle moves with variable velocity, which of the following statement are Not correct?

(i) Average speed = average velocity

(ii) Instantaneous speed = instantaneous velocity

(iii) Distance covered = magnitude of displacement

(a) (i), (ii) & (iii)
(b) (i) & (ii)
(c) (ii) & (iii)
(d) (i) & (iii) only

AP EAMCET-06.09.2021, Shift-II

Ans. (d) : average speed $= \dfrac{\text{distance travelled}}{\text{time taken}}$

average velocity $= \dfrac{\text{displacement}}{\text{time taken}}$

$\therefore$ displacement $\le$ distance

i.e. average speed $\ne$ average velocity

But for an instant of time, magnitude of velocity and speed, both are equal

Hence, option (d) is correct

294. Assertion (A) : An object can possess acceleration even at a time when it has a uniform speed.

Reason (R) : It is possible when the direction of motion keeps changing.

(a) Both A and R are true and R is a correct explanation for A
(b) Both A and R are true but R is not a correct explanation for A
(c) A is true. R is false
(d) A is false. R is true

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (a) : Both A and R are true and R is correct explanation for A

We know that, An object can possess acceleration even at a time when it has uniform speed because, it is possible when the direction of motion keeps changing.

e.g. Uniform circular motion

295. Acceleration of a body whose displacement follows the equation $3s = 9t + 5t^2$ is ______

(a) $\frac{5}{3}$
(b) $\frac{14}{3}$
(c) $\frac{10}{3}$
(d) $\frac{19}{3}$

AP EAMCET-25.08.2021, Shift-II

Ans. (c) : Acceleration of a body when displacement equation – $3s = 9t + 5t^2$

$$\frac{3ds}{dt} = 9 + 10t \quad \text{(differentiating both side w.r.t, t)}$$

$$\frac{ds}{dt} = \frac{9+10t}{3}$$

Again differentiating w.r.t., t

$$\frac{d^2s}{dt^2} = \frac{10}{3}$$

296. The velocity of a particle is given by $v = 2t^2 - 8t + 15\text{ ms}^{-1}$. Find its instantaneous acceleration at t = 5s.

(a) 18 m.s^{-2}
(b) 20 m.s^{-2}
(c) 5 m.s^{-2}
(d) 12 m.s^{-2}

AP EAMCET-23.08.2021, Shift-I

Ans. (d) : Given,

Velocity (v)=$2t^2 - 8t + 15\quad \text{m.s}^{-1}$

t = 5s

$$\because\ v = 2t^2 - 8t + 15$$

$$\frac{dv}{dt} = \frac{d}{dt}(2t^2 - 8t + 15)$$

$$\Rightarrow \frac{dv}{dt} = 2\frac{d}{dt}t^2 - 8\frac{d}{dt} + \frac{d}{dt}15$$

$$\Rightarrow \frac{dv}{dt} = 4t - 8 + 0$$

$$\Rightarrow \frac{dv}{dt} = 4t - 8$$

We know that,

Acceleration $= \dfrac{dv}{dt}$

Acceleration = 4t – 8

at t = 5

Then, Acceleration = 4×5–8

Acceleration = 20–8

Acceleration =12 ms^{-2}

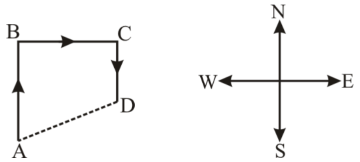
297. To reach point-B from point-A, a person travels 500 m North, 400 m East and 200 m south. If the person takes 1200 seconds to reach point-B from point-A then find the average velocity of the person ________

(a) $\frac{5}{12}\text{ m. s}^{-1}$
(b) $\frac{5}{20}\text{ m. s}^{-1}$
(c) $\frac{10}{3}\text{ m. s}^{-1}$
(d) $\frac{12}{5}\text{ m. s}^{-1}$

AP EAMCET-05.10.2021, Shift-I

@apna_pdf

Ans. (a) :



$$\text{Distance} = AB + BC + CD$$
$$= (500 + 400 + 200)$$
$$= 1100\text{m}$$

$$\text{Displacement} = AD = \sqrt{(AB - CD)^2 + BC^2}$$
$$= \sqrt{(500 - 200)^2 + 400^2}$$
$$= 500\text{m}$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$
$$\frac{1100}{1200} = \frac{11}{12}\text{ m/s}$$

$$\text{Average Velocity} = \frac{AD}{t} = \frac{500}{1200}$$

$$\text{Average velocity} = \frac{5}{12}\text{ms}^{-1}$$

298. A particle is at x = 0 when t = 0. It moves among x-axis with a velocity given by v = $5\sqrt{x}$. Find the acceleration of this particle ______

(a) 8.5 m. s^{-2} (b) 12.5 m. s^{-2}

(c) 10.5 m. s^{-2} (d) 11.5 m. s^{-2}

AP EAMCET-05.10.2021, Shift-I

Ans. (b) : We know that

Acceleration = derivative of speed with respect to time

Therefore,

$$a = \frac{dv}{dt}$$
$$a = \frac{dv}{dx} \times \frac{dx}{dt}$$
$$a = d(5\sqrt{x})/dx \times \frac{dx}{dt}$$
$$a = \frac{5}{2\sqrt{x}} \times v \qquad (v = 5\sqrt{x})$$
$$a = \left(\frac{5}{2\sqrt{x}}\right) \times 5\sqrt{x}$$
$$a = \frac{5}{2} \times 5 = \frac{25}{2} = 12.5\text{m/s}^2$$

Therefore, $\boxed{\text{acceleration is } 12.5\text{m/s}^2}$

299. Which of the following decreases, in motion on a straight line, with constant retardation?

(a) Speed (b) Acceleration

(c) Displacement (d) Distance

AP EAMCET-19.08.2021, Shift-I

Ans. (a) : When a body moves along a straight line with constant retardation, its speed goes on decreasing as it goes on covering less distance.

300. The acceleration (a) of an object varies as a function of its velocity (v) as a = $\lambda\sqrt{v}$ where λ is a constant. If at t = 0, v = 0, then the velocity as a function of time (t) is given as

(a) $\frac{3}{4}\lambda^2 t^3$ (b) $\frac{1}{4}\lambda t$

(c) $\frac{1}{4}\lambda^2 t^2$ (d) $\frac{1}{4}\lambda^2 t$

UPSEE 2020

Ans. (c) : We know that,

$$a = \frac{dv}{dt} \qquad \{ a = \lambda\sqrt{v} \text{ - given}\}$$

dv = a.dt

Integration both side

$$\int_0^v \frac{dv}{\sqrt{v}} = \lambda \int_{t=0}^{t} dt$$
$$\left[2\sqrt{v}\right]_0^v = \lambda[t]_0^t$$
$$2\sqrt{v} = \lambda[t - 0]$$

Squaring both side

$$4v = \lambda^2 t^2$$
$$v = \frac{\lambda^2 t^2}{4}$$

301. Find the relation between 'x' and 'y', when a body starting from rest, moves with uniform acceleration and travels a distance x in the first n seconds and y in the next n seconds:

(a) 3x = y (b) x = 3y

(c) x = y (d) x = 2y

AP EAMCET-25.09.2020, Shift-I

Ans. (a) : From given question.

The distance covered in 2 sec, $x = \frac{1}{2}a(2)^2 = 2a$

and the distance covered in next 2 sec,

$$y = \frac{1}{2}.a(4)^2 - \frac{1}{2}a.(2)^2$$

y = 6a

So, $\frac{x}{y} = \frac{2a}{6a} = \frac{1}{3}$

$3x = y \Rightarrow \boxed{y = 3x}$

302. Distances travelled by a body in first three successive equal intervals of time are in the ratio ………, if it starts from rest and moves with uniform acceleration:

(a) 1 : 2 : 3 (b) 1 : 3 : 5

(c) 1 : 2^2 : 3^2 (d) 1 : 3^2 : 5^2

AP EAMCET-25.09.2020, Shift-I

@apna_pdf

Ans. (b) : Let at is the equal interval of time and initial velocity, u= 0

Now, Distance travelled in first time interval,

$D_1 = \frac{1}{2}a\Delta t^2$ ......(i)

similarly,

Distance travelled in second time interval,

$$D_2 = \frac{1}{2}a(2\Delta t)^2 - \frac{1}{2}a\Delta t^2 = \frac{3}{2}a\Delta t^2 \quad \text{.........(ii)}$$

and $D_3 = \frac{1}{2}a(3\Delta t)^2 - \frac{1}{2}a(2\Delta t)^2 = \frac{5}{2}a\Delta t^2$ ....(iii)

So, By equation (i), (ii), (iii)

$D_1 : D_2 : D_3 = 1 : 3 : 5$

hence option (b) is correct

303. Motion of a particle is given by equation s = $(3t^3 + 7t^2 + 3t + 8)$ m. The acceleration of the particle at t = 1 seconds is

(a) 32 $m.s^{-2}$ (b) 10 $m.s^{-2}$

(c) 16 $m.s^{-2}$ (d) 23 $m.s^{-2}$

AP EAMCET-07.10.2020, Shift-I

Ans. (a) : Given equation, $s = (3t^3 + 7t^2 + 3t + 8)$m

acceleration, a = ? at t = 1 sec

$\because$ We know that, velocity $v = \frac{ds}{dt} = 9t^2 + 14t + 3$

and acceleration, $a = \frac{dv}{dt} = 18t + 14$

Now, at t = 1 sec

$a = 18 \times 1 + 14$

$a = 32\ m.s^{-2}$

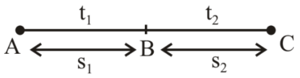
304. Find the initial velocity of a body moving with a uniform acceleration covering 40 m in the first 5 seconds and 65 m in the next 5 seconds?

(a) 11 m. s^{-1} (b) 5.5 m. s^{-1}

(c) 2.5 m. s^{-1} (d) 4 m. s^{-1}

AP EAMCET (Medical)-07.10.2020, Shift-I

Ans. (b) : Given by, $s_1 = 40m$, $s_2 = 65m$



$s_1 = ut + \frac{1}{2}at^2$ ....(i)

$s_2 = vt + \frac{1}{2}at^2$

Velocity after t sec

$v = u + at$

$s_2 = (u + at)t + \frac{1}{2}at^2$ ....(ii)

$\therefore s_2 - s_1 = at^2$

So, $a = \frac{s_2 - s_1}{t^2} = \frac{65 - 40}{25} = 1 m/s^2$

Now, by equation (i)

$$s_1 = ut + \frac{1}{2}at^2$$

$40 = 5u + \frac{1}{2} \times 1 \times (5)^2$

u = 5.5 m/s

305. The position of an object moving along X-axis is given by $x = \alpha + \beta t^2$, where α and β are constants with appropriate dimensions and t is time in seconds. The average velocity between t = 2s and 4s is 12 m/s. If α = 8m, then the value of β is

(a) 0.5 m/s^2 (b) 2 m/s^2

(c) 4 m/s^2 (d) 5 m/s^2

TS-EAMCET-09.09.2020, Shift-2

Ans. (b): Given,

Position is given as $x = \alpha + \beta t^2$

Position at t = 2s $(x_1) = \alpha + 4\beta$

Position at t = 4s $(x_2) = \alpha + 16\beta$

$\therefore$ Displacement of object $(\Delta x) = x_2 - x_1$

$= (\alpha + 16\beta) - (\alpha + 4\beta)$

$= 12\beta$

Average velocity $(V_{avg}) = \frac{\Delta x}{\Delta t} = \frac{12\beta}{(4-2)}$

$12 = \frac{12\beta}{2}$

$\beta = 2 m/s^2$

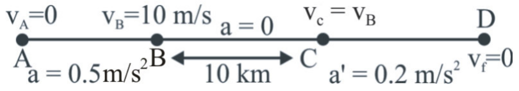
306. A motor-bike starts from rest, attains a velocity of 10 m/s with an acceleration of 0.5 m/s^2, travels 10 km with this uniform velocity and then comes to halt with a uniform deceleration of 0.2 m/s^2. The total time of travel is

(a) 1070 s (b) 1050 s

(c) 1150 s (d) 1170 s

TS-EAMCET.14.09.2020, Shift-2

Ans. (a) : The given situation of entire motion of motor bike is shown in the figure.



If time taken by the motorbike to reach from point A to B is t_{AB}, then for A to B,

$v_A = 0,\ v_B = 10\ ms^{-1},\ a = 0.5\ ms^{-2}$

$\therefore$ From equation, v = u + at

$v_B = v_A + at_{AB} \Rightarrow 10 = 0 + 0.5t_{AB}$

$\Rightarrow \quad t_{AB} = \frac{10}{0.5} = 20$ s

Since, motorbike moves from point B to C with constant velocity. Hence, time taken to travel distance BC is given as

$$t_{BC} = \frac{BC}{v_B} = \frac{10km}{10ms^{-1}} = \frac{10000\ m}{10\ ms^{-1}} = 1000\ s$$

@apna_pdf

For motion of motorbike from point C to D, time = t_{CD}, $v_B = 10\ ms^{-1}$, $v_f = 0$, $a' = 0.2\ ms^{-2}$

From equation, $v = u - at$,

$$v_f = v_B - a't_{CD}$$

$$0 = 10 - 0.2 \times t_{CD} \Rightarrow t_{CD} = 50\ s$$

$$\therefore \text{ Total time} = t_{AB} + t_{BC} + t_{CD}$$

$$= 20\ s + 1000\ s + 50\ s = 1070\ s$$

307. A body moves in a straight line with speed v_1 and v_2 for distance which are in ratio 1 : 2. Find the average speed.

(a) $3v_1 + v_2$ (b) $v_2 + 2v_1$

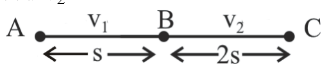
(c) $\dfrac{3v_1v_2}{v_2 + 2v_1}$ (d) $\dfrac{3v_1v_2}{v_2 - 2v_1}$

TS-EAMCET-14.09.2020, Shift-1

Ans. (c) : Given that,

The distances travelled by the body are in ratio 1 : 2.

Suppose that s is the distance travelled by the body with speed v_1 and 2s will be the distance travelled by the body with speed v_2



For A to C –

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$V_{avg} = \frac{s_1 + s_2}{t_1 + t_2}$$

$$V_{avg} = \frac{s + 2s}{\frac{s}{v_1} + \frac{2s}{v_2}}$$

$$V_{avg} = \frac{3s}{s\left[\frac{1}{v_1} + \frac{2}{v_2}\right]} = \frac{3}{\left[\frac{v_2 + 2v_1}{v_1v_2}\right]}$$

$$V_{avg} = \frac{3v_1v_2}{v_2 + 2v_1}$$

308. The displacement of a body when it covers a distance of C/4 (where, C is circumference) along the circumference of the circle of radius r with a uniform speed u is

(a) r (b) $r\sqrt{2}$

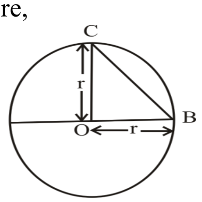
(c) $2r$ (d) $\dfrac{r}{2}$

AP EAMCET (18.09.2020) Shift-I

Ans. (b) : Displacement is the distance between the initial and final position of any object. Let initial point is B and final point is C.

So, displacement = BC

Therefore,



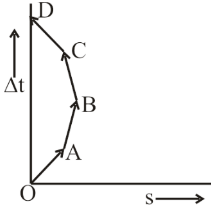
Displacement, $BC = \sqrt{OB^2 + OC^2}$

$$BC = \sqrt{r^2 + r^2}$$

$$BC = \sqrt{2r^2}$$

$$BC = r\sqrt{2}$$

309. Which of the following options is correct for the object having a straight-line motion represented by the following graph?



(a) The object moves with constantly increasing velocity from O to A and then it moves with constant velocity

(b) Velocity of the object increases uniformly.

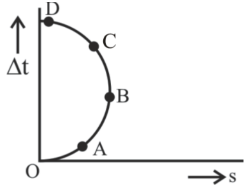
(c) Average velocity is zero

(d) The graph shown is impossible.

AP EAMCET (18.09.2020) Shift-I

Ans. (c) : From figure, displacement = 0

($\because$ at point O and D displacement s = 0)



$$\text{So, Average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

$$\text{Average velocity} = \frac{0}{t} = 0$$

310. A body is moving with an initial velocity of $10\sqrt{2}\ ms^{-1}$ in the north-east direction. If it is subjected to an acceleration of $2ms^{-2}$ directed towards the south, then velocity of the body after 5s is

(a) $10ms^{-1}$, towards east

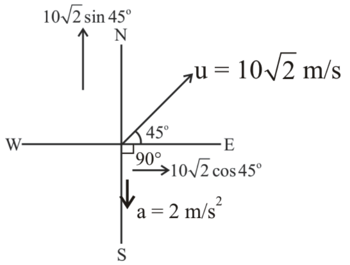
(b) $10ms^{-1}$, towards north

(c) $10ms^{-1}$, towards south

(d) $10ms^{-1}$, towards north-east

AP EAMCET (17.09.2020) Shift-I

Ans. (a) :



@apna_pdf

$u = 10\sqrt{2}$ m/s

$u_x = u\cos\theta$

From figure, at initial level,

$t = 0$ and $u_x = 10\sqrt{2}\cos45^o$

$u_x = 10\sqrt{2} \times \frac{1}{\sqrt{2}}$

$u_x = 10$ m/s

Similarly,

$u_y = 10\sqrt{2}\sin45^o = 10\sqrt{2} \times \frac{1}{\sqrt{2}} = 10$ m/s

$u_y = 10$ m/s

From equation of motion velocity at t = 5 sec long east direction

$v_x = u_x + a_x t$

Acceleration along east direction = a cos90° = 0

$v_x = 10 + (2\cos90°) \times 5 = 10 + 0$

$v_x = 10$ m/s

At,

$t = 5s, \quad V_y = U_y + at$

$v_y = 10 + (-2) \times 5 = 10 - 10 = 0$

Therefore, $V = V_x + V_y$

$= 10 + 0$

V = 10 m/s towards east

311. When will a body of mass 20 kg moving at 15 ms^{-1}, subjected to a retarding force of 100 N, come to rest?

(a) 3 s (b) 6 s

(c) 1.5 s (d) 9 s

AP EAMCET (23.09.2020) Shift-I

Ans. (a) : Given data, mass (m) = 20 kg

force (F) = 100 N

By Newton's second Law

F = ma

By the retardation of acceleration = –a

$\therefore \quad -a = \frac{F}{m} = \frac{100}{20} = 5\,\text{m/s}^2$

$a = -5\text{m/s}^2$

When body come to rest, v = 0

Now, from the equation of motion

$v = u + at$

$0 = 15 + (-5)\,t$

$5t = 15$

$t = 3s$

312. The acceleration at the end of 2s, of a particle whose motion is represented by the equation s = 4t^3 – 8t^2 + 5t + 4 is

(a) 32 ms^{-2} (b) 40 ms^{-2}

(c) 37 ms^{-2} (d) 35 ms^{-2}

AP EAMCET (23.09.2020) Shift-I

Ans. (a) :

Given equation of motion, $s = 4t^3 - 8t^2 + 5t + 4$

Acceleration at t = 2 s

We know that, velocity $v = \frac{ds}{dt}$

$v = \frac{ds}{dt} = \frac{d(4t^3 - 8t^2 + 5t + 4)}{dt}$

$v = 12t^2 - 16t + 5$

and also acceleration (a) $= \frac{dv}{dt}$

i.e. again differentiate equation of velocity w.r.t time.

$a = \frac{dv}{dt} = \frac{d(12t^2 - 16t + 5)}{dt}$

$a = 24t - 16$

At, $t = 2s$

$a = 24 \times 2 - 16$

$a = 48 - 16$

$\boxed{a = 32\text{m/s}^2}$

313. A body whose momentum is constant must have constant

(a) acceleration (b) force

(c) velocity (d) mass

AP EAMCET (22.09.2020) Shift-II

Ans. (c) : Momentum equation, p = mv

P = mass × velocity

So, for the constant momentum, velocity must be constant.

314. A body of mass 5 kg starts from the origin with an initial velocity $u = 30\hat{i} + 40\hat{j}\,\text{ms}^{-1}$. When a constant force $F = -(\hat{i} + 5\hat{j})$ N acts on the body, the time in which the y-component of the velocity becomes zero is

(a) 5 s (b) 20 s

(c) 40 s (d) 80 s

AP EAMCET (22.09.2020) Shift-I

Ans. (c) : Given that, mass of body, m = 5kg

Initial velocity, $u = 30\hat{i} + 40\hat{j}\,\text{m/s}$ i.e. $u_y = 40$ m/s

Constant force, $F = -(\hat{i} + 5\hat{j})$ N i.e. $F_y = -5$ N

The time when y –component of the velocity becomes zero = ?

For y - direction, acceleration $a = \frac{F}{m} = \frac{-5}{5}$

$a = -1$ m/s

Now, By the equation of motion

$v = u + at$

$v_y = u_y + at$

$0 = 40 + (-1) \times t$

$40 = t$

i.e. $\boxed{t = 40s}$

So, the time in which y-component of the velocity becomes zero is 40 sec.

@apna_pdf

315. A bomb is dropped from an aeroplane flying horizontally with a velocity 720 km/hr at an altitude of 980 m. The bomb will hit the ground after a time.

(a) 1 s (b) 7.2 s
(c) 14.15 s (d) 0.15 s

MHT-CET 2020

Ans. (c) : Given,

$u = 0$, $h = 980$ m, $g = 9.8 \text{m/s}^2$, $v = 720$ km/h

$$h = ut + \frac{1}{2}gt^2$$

$$980 = 0 + \frac{1}{2} \times 9.8 \times t^2$$

$$t^2 = \frac{980 \times 2}{9.8}$$

$$t = 10\sqrt{2}$$

$t = 14.14$ sec

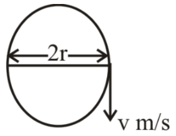
316. A particle is moving along the circular path of radius 'r' with velocity 'v'. The magnitude of average acceleration after half revolution is

(a) $\frac{3v^2}{\pi r}$ (b) $\frac{3v^2}{2\pi r}$
(c) $\frac{2v^2}{\pi r}$ (d) $\frac{v^2}{\pi r}$

MHT-CET 2020

Ans. (c) :

Time taken to complete half revolution = $\frac{\pi r}{v}$



In half revolution,

Change of momentum, $\Delta P = mv - m(-v)$
$= mv + mv$
$= 2mv$

Average force (F) = Rate of change in momentum

$$ma = \frac{\Delta P}{\Delta t}$$

$$ma = \frac{2mv}{\frac{\pi r}{v}}$$

$$a = \frac{2v^2}{\pi r}$$

317. A car starts from Bengaluru, goes 50 km in a straight line towards south, immediately turns around and returns to Bengaluru. The time taken for this round trip is 2 hours. The magnitude of the average velocity of the car for this round trip

(a) is 0.
(b) 50 km/hr
(c) 25 km/hr
(d) cannot be calculated without knowing acceleration

NDA (II) 2019

Ans. (a): Given that,

Distance covered in one side
$(d_1) = 50$ km

The distance covered in returning
$(d_2) = 50$ km

Displacement = $d_1 - d_2$
$x = 50 - 50 = 0$

$$\text{Average velocity} = \frac{\text{Total Displacement}}{\text{time}}$$

$$v_{avg} = \frac{0}{2}$$

$v_{avg} = 0$

318. An object having a velocity 5 m/s is accelerated at the rate 2 m/s^2 for 6 s. Find the distance travelled during the period of acceleration

(a) 60 m (b) 25 m
(c) 36 m (d) 66 m
(e) 45 m

Kerala CEE-2019

Ans. (d) : Given- $u = 5$ m/s, $a = 2\text{m/s}^2$, $t = 6$s

$$s = ut + \frac{1}{2}at^2$$

$$s = 5 \times 6 + \frac{1}{2} \times 2 \times 6^2$$

$$\boxed{s = 66 \text{ m}}$$

319. The variation of speed (in m/s) of an object with time (in seconds) is given by the expression $V(t) = V_0 - 5t + 5t^2$

(a) At time t=0s, the instantaneous acceleration is zero
(b) At time t=0s, there is a deceleration of the object
(c) At time t=1 s, the object is at rest
(d) At time t= 1s, the instantaneous acceleration is zero
(e) The distance travelled by the object at time t= 1 s is V_0 m

Kerala CEE-2019

Ans. (b) :

⇒ The velocity of a object is given by equation

$V(t) = V_0 - 5t + 5t^2$

Acceleration-

$$a = \frac{dV}{dt} = \frac{d}{dt}\left(V_0 - 5t + 5t^2\right) \Rightarrow -5 + 10t$$

at , t=0 s the acc^{in} of object

$a = -5 + 10 \times 0 = -5 \text{m/s}^2$

so, at time t=0 there is deceleration of object

at t=1s, $V = V_0 - 5 + 5$

$$\boxed{V = V_0 \text{m/s}}$$

and $a = -5 + 10 \times 1 = +5 \text{m/s}^2$

So, at t = 0, there is non zero and positive value of velocity and acceleration

@apna_pdf

320. The magnitude of deceleration required for a body, moving at a speed of 10 m/s to come to a complete halt at a distance of 100 m is

(a) 20 m/s^2
(b) 10 m/s^2
(c) 2 m/s^2
(d) 0.5 m/s^2
(e) 1m/s^2

Kerala CEE-2019

Ans. (d) :

⇒ Given u = 10 m/s , s= 100m , v=0

from equation of motion

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$0 - (10)^2 = 2 \times a \times 100$$

$$\Rightarrow \quad a = -\frac{100}{2 \times 100}$$

$$\boxed{a = -0.5 m/s^2}$$

So, deceleration is 0.5 m/s^2

321. A 5.0 g bullet moving at 100 m/s strikes a wooden block. Assuming that the bullet undergoes a uniform deceleration and stops after penetrating a distance of 5 cm. The time taken by the bullet to stop and the impulse on the block are respectively

(a) 4.5 ms and 3.2 N–s
(b) 3.5 ms and 2.1 N–s
(c) 2.7 ms and 1.5 N–s
(d) 1.0 ms and 0.5 N–s

AMU-2019

Ans. (d) : Given,

$$m = 5 \times 10^{-3} kg$$

$$u = 100 m/s$$

$$v = 0$$

$$s = 5cm = 0.05m$$

According to the third law of motion

$$v^2 = u^2 - 2as$$

$$u^2 = 2as \ (\because v = 0)$$

$$(100)^2 = 2 \times a \times 0.05$$

$$a = 10(100)^2 \ m/sec^2$$

Now, according to the first law of motion

$$v = u - at$$

$$\Rightarrow u = at$$

$$\Rightarrow t = \frac{u}{a} = \frac{100}{10 \times (100)^2} sec$$

$$\Rightarrow t = 1 \times 10^{-3} sec$$

t = 1 ms

Now,

Impulse = f × Δt = mΔv (here mass is constant)

$$= 5 \times (10)^{-3} \times 100$$

Impulse = 0.5 N – sec

322. Assertion: The equation of motion can be applied only if acceleration is along the direction of velocity and is constant.

Reason: If the acceleration of the body is constant then its motion is known as uniform motion.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-26.05.2019(E) Shift-2

Ans. (d): Equation of motion can be applied if the acceleration is in opposite direction to that of velocity and uniform motion mean the acceleration is zero.

Hence, both assertion and reason are false.

323. A 175 m long train is travelling along a straight track with a velocity 72 kmph. A bird is flying parallel to the train in the opposite direction with a velocity 18 kmph. The time taken by the bird to cross the train is

(a) 35 s
(b) 27 s
(c) 11.6 s
(d) 7 s

COMEDK 2019

Ans. (d) : Given,

Velocity of bird = 18 km/h
Velocity of train = 72 km/h
Length of train = 175 m

Velocity of bird with respect to train (v)

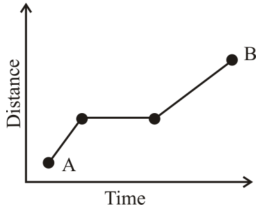
$$= 18 + 72 = 90 \text{ km/h} \times \frac{5}{18} = 25 ms^{-1}$$

Length to be covered by bird with respect to train to cross the train (s) = 175 m

Hence, time taken by bird to cross the train

$$t = \frac{s}{v} = \frac{175}{25} = 7 sec$$

324. A particle covers a distance from A to B over a period of time, the distance versus time plot is shown below. Then which of the following is true for the motion of the particle?

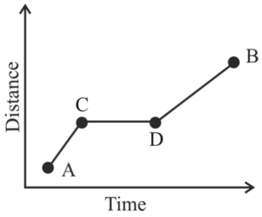


(a) Both average speed and instantaneous speed are always zero.
(b) Average speed is always non-zero but instantaneous speed can be zero.
(c) Instantaneous speed is always non-zero but average speed can be zero.
(d) Both average speed and instantaneous speed are always non-zero.

TS-EAMCET-04.05.2019, Shift-2

@apna_pdf

Ans. (b) :



From the graph, the slope of distance time graph for position A to C and D to B is always positive. Therefore both the average speed and instantaneous speed are not always zero. So, option (a) is not correct.

$$\text{Average velocity} = \frac{\text{Total displacement from A to B}}{\text{Total time interval}}$$

Since, total displacement depends on initial and final points. Hence, displacement between A to B is always non zero.

But no distance is travelled between point C and D. Hence, Instantaneous speed between point C to D is zero.

325. Consider a car initially at rest, starts to move along a straight road first with acceleration 5 m/s^2, then with uniform velocity and finally, decelerating at 5 m/s^2, before coming to a stop. Total time taken from start to end is t = 25 s. If the average velocity during that time is 72 km/hr, the car moved with uniform velocity for a time of

(a) 15 s (b) 30 s
(c) 155 s (d) 2 s

TS-EAMCET-03.05.2019, Shift-2

Ans. (a) : Given that,

Acceleration of car (a) = 5m/s^2
Deceleration of car (a) = 5m/s^2
Total time taken (t) = 25 s

Average velocity of car (V_{avg}) = $72 \times \frac{5}{18} = 20\text{m/s}$

$$V_{avg} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

Total time taken by the car during acceleration and deceleration is 2t.

$$V_{avg} = 20 = \frac{d_t + d_{(25-2t)} + d_t}{25}$$

$$20 = \frac{2d_t + d_{(25-2t)}}{25}$$

Now, $d_t = 0 + \frac{1}{2}at^2$

$$= \frac{1}{2}at^2$$

$$d_t = \frac{5}{2}t^2 \text{ and } d_{(25-2t)} = V_{uni}(25-2t)$$

Where $V_{uni} = 5t$

Then, $$V_{avg} = 20 = \frac{2\left(\frac{5}{2}t^2\right) + 5t(25-2t)}{25}$$

∴ $20 \times 25 = 5t^2 + 5t\,(25-2t)$
$500 = 5t^2 + 125t - 10t^2$
$t^2 - 25t + 100 = 0$
t = 20s and 5s

As t cannot be 20 sec as it does not satisfy the condition.

∴ We take t = 5 sec.

So, the time of uniform motion = 25 –2t
= 25 – 2 × 5
= 15 sec

326. A body of mass 8 kg is moved by a force F=3 x N, where x is the distance covered. Initial position is x = 2m and the final position is x = 10m. The initial speed is zero. The final speed is

(a) 6 m/s (b) 12 m/s
(c) 18 m/s (d) 14 m/s

Manipal UGET-2019

Ans. (a) : Given that, Mass = 8 kg, F = 3x N

We know, acceleration is given by a = $\frac{F}{m}$

$$v^2 = u^2 + 2as \qquad (\because u = 0,\ s = x)$$
$$v^2 = 0 + 2as$$
$$v^2 = 2as$$
$$v^2 = 2\int \frac{F}{m}dx$$

Assuming that body begins from rest

$$v^2 = 2\int_2^{10} \frac{3x}{8}dx = \frac{3}{4}\int_2^{10} x dx$$
$$v^2 = \frac{3}{4}\left(\frac{10^2}{2} - \frac{2^2}{2}\right)$$
$$v^2 = \frac{3}{8}(100-4) \Rightarrow v^2 = \frac{3}{8}\times 96$$
$$v^2 = 36$$
$$v = 6 \text{ m/s}$$

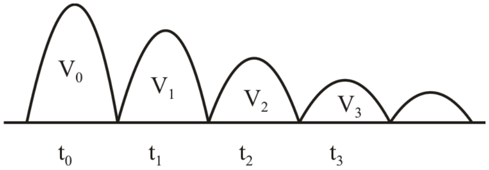
327. A ball falls freely from a height of 180 m on to a hard horizontal floor and repeatedly bounces. If the coefficient of restitution is 0.5, the average speed and average velocity of the ball before it ceases to rebound are respectively (acceleration due to gravity = 10 ms^{-2})

(a) 10ms^{-1}, 10ms^{-1}
(b) 50ms^{-1}, $\frac{50}{3}$ms^{-1}
(c) $\frac{50}{3}$ms^{-1}, 10ms^{-1}
(d) $\frac{20}{3}$ms^{-1}, $\frac{50}{3}$ms^{-1}

AP EAMCET (20.04.2019) Shift-1

@apna_pdf

Ans. (c) : Given data,



Height of falls of a ball h = 180 m

Coefficient of restitution $e = 0.5 = \frac{1}{2}$

Average speed = ?

And average velocity = ?

For a given heigh h, speed $v_0 = \sqrt{2gh}$

And $t_0 = \sqrt{\frac{2h}{g}}$

After first collision, it speed will become

$$v_1 = ev_0 = e\sqrt{2gh}$$

When the ball is stops,

$$v = u + at$$

$$0 = v_1 - gt_1$$

$$t_1 = \frac{v_1}{g}$$

Now, the ball will come down and take same time t_1 before second collision.

∴ Total time taken = $2t_1$

Similarly, for second

$$2t_2 = \frac{2v_2}{g}$$

Total time before it ceases to rebound

$$T = t_0 + 2t_1 + 2t_2 + \text{........}$$

$$T = t_0 + 2\frac{v_1}{g} + \frac{2v_2}{g} + \text{.......}$$

$$T = t_0 + \frac{2ev_0}{g} + \frac{2e^2v_0}{g} + \text{.......} \qquad (\because\ v_2 = ev_1 = e^2v_0)$$

$$T = \sqrt{\frac{2h}{g}}\left[1 + 2e\left(1 + e + e^2 + e^3 + \text{.......}\right)\right] \left(\begin{array}{l}\because v_0 = \sqrt{2gh} \\ \text{and } t_0 = \sqrt{\frac{2h}{g}}\end{array}\right)$$

It is form of a G.P.

$$\therefore \quad T = \sqrt{\frac{2h}{g}}\left[1 + 2e\left(\frac{1}{1-e}\right)\right]$$

$$T = \sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right) \Rightarrow T = \sqrt{\frac{2\times180}{10}}\left(\frac{1+0.5}{1-0.5}\right)$$

$$\boxed{T = 18\text{s}}$$

As we know,

$$e = \frac{v}{u} = \sqrt{\frac{2gh_1}{2gh_0}} = \sqrt{\frac{h_1}{h}} \Rightarrow h_1 = e^2h \text{ and } h_2 = e^2(e^2h) = h_2 = e^4h$$

So, Total distance, $H = h_0 + 2h_1 + 2h_2 + \text{.........}$

$$H = h\left[1 + 2e^2\left(1 + e^2 + e^4 + \text{........}\right)\right]$$

$$H = h\left[1 + 2e^2\left(\frac{1}{1-e^2}\right)\right]$$

$$H = h\left(\frac{1+e^2}{1-e^2}\right) \Rightarrow 180\left(\frac{1+\frac{1}{4}}{1-\frac{1}{4}}\right) = 300$$

$$\boxed{H = 300\text{m}}$$

Average speed $v = \frac{300}{18} = \frac{50}{3}\,\text{m/s}$

Average velocity, $v = \frac{180}{18} = 10\,\text{m/s}$

Hence option (c) is correct.

328. The motion of a particle along a straight line is described by the function, $x = (2t - 3)^2$ Where x is in metres and t is in seconds. The acceleration of the particle at t = 2s is

(a) 1 ms^{-2} (b) 4 ms^{-2}
(c) 8 ms^{-2} (d) 7 ms^{-2}

AP EAMCET (20.04.2019) Shift-1

Ans. (c) : Given equation of motion, $x = (2t - 3)^2$

or $x = 4t^2 + 9 - 12t$

$x = 4t^2 - 12t + 9$

We know that velocity, $v = \frac{dx}{dt}$

So, differentiate the equation of x w.r.t ‘t’

$$\frac{dx}{dt} = 8t - 12 \Rightarrow v$$

Again differentiating of $\frac{dx}{dt}$ w.r.t.‘t’

$$\frac{d^2x}{dt^2} = 8 \Rightarrow a$$

acceleration $\boxed{a = 8\,\text{m/s}^2}$

Hence option (c) is correct.

329. A car moving with a velocity 6.25 ms^{-1} is decelerated with $2.5\sqrt{v}\ \text{ms}^{-2}$ (v is instantaneous velocity). Time taken by the car to come to rest is.

(a) 2 s (b) 3 s
(c) 2.5 s (d) 4 s

AP EAMCET (23.04.2019) Shift-I

Ans. (a) :

Given that, initial velocity of car, u = 6.25 m/s

$a = 2.5\sqrt{v}$ m/s^2 deceleration

Time taken by car to come at rest = ?

So, acceleration $a = \frac{dv}{dt} = -\,2.5\sqrt{v}$

$$\frac{dv}{\sqrt{v}} = -2.5\,dt$$

@apna_pdf

Now on integrating both side w.r.t 't'

$$\int_{6.25}^{0}\frac{dv}{\sqrt{v}}=-2.5\int dt$$

$$\left[2\sqrt{v}\right]_{6.25}^{0}=-2.5t$$

$$2\left(\sqrt{0}-\sqrt{6.25}\right)=-2.5t$$

$$-2\sqrt{6.25}=-2.5t$$

$$t=\frac{2\times2.5}{2.5}$$

$$\boxed{t=2\,s}$$

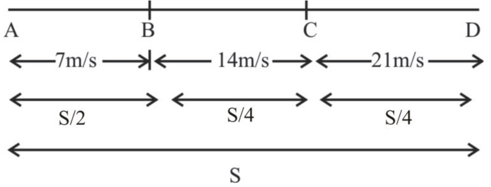
330. A body travelling along a straight line path travels first half of the distance with a velocity 7ms^{-1}. During the travel time of the second half of the distance, first half time is travelled with a velocity 14ms^{-1} and the second half time is travelled with a velocity 21ms^{-1}. Then the average velocity of the body during the journey is

(a) 14ms^{-1} (b) 10 ms^{-1}

(c) 9 ms^{-1} (d) 12 ms^{-1}

AP EAMCET (22.04.2019) Shift-I

Ans. (b) : From question we can draw the figure as



So total distance = S

Let first half distance is travelled in time t_1 and BC distance is travelled in time t_2 and CD distance is travelled in time t_3.

As we know velocity = $\frac{\text{distance}}{\text{time}}$

$$v=\frac{d}{t}\Rightarrow t=\frac{d}{v}$$

For,

$$AB,\ t_1=\frac{s/2}{7}=\frac{s}{14}\text{ sec}$$

For,

BC, $v_2 = 14$ m/s

$$t_2=\frac{BC}{v_2}$$

$$BC = 14t_2$$

For, DC

$v_3 = 21$ m/s

$$t_3=\frac{DC}{v_3}$$

$$DC = 21t_3$$

According to question $t_2 = t_3$

$$\frac{BC}{14}=\frac{DC}{21}$$

$$\frac{BC}{DC}=\frac{2}{3}$$

Distance BD (S/2) divide in ratio 2 : 3

Then, $BC=\frac{2}{5}\times\frac{S}{2}=\frac{2S}{10}$

$$t_2=\frac{BC}{v_2}=\frac{\frac{2S}{10}}{14}=\frac{S}{70}$$

$$CD=\frac{3}{5}\times\frac{S}{2}=\frac{3S}{10}$$

$$t_3=\frac{CD}{v_3}=\frac{\frac{3S}{10}}{21}=\frac{S}{70}$$

$$V_{avg}=\frac{\text{Total distance}}{\text{Total time}}$$

$$V_{avg}=\frac{S}{\left(\frac{S}{14}+\frac{S}{70}+\frac{S}{70}\right)}$$

$$=\frac{1}{\left(\frac{5+1+1}{70}\right)}=\frac{70}{7}$$

$V_{avg} = 10$ m/s

331. The speed of a particle changes from $\sqrt{5}$ ms^{-1} to $2\sqrt{5}$ ms^{-1} in a time. If the magnitude of changes in its velocity is 5 ms^{-1}, the angle between the initial and final velocities of the particle is

(a) 30° (b) 45° (c) 60° (d) 90°

AP EAMCET (21.04.2019) Shift-I

Ans. (d) : Given that, $v_i = \sqrt{5}$ m/s, $v_f = 2\sqrt{5}$ m/s

$\Delta v = 5$ m/s

As we know

$$R^2 = A^2 + B^2 + 2AB\cos\theta$$

$$\therefore\quad \cos\theta=\frac{R^2-A^2-B^2}{2AB}$$

In given question, initial velocity and final velocity are extreme speeds i.e. at t = 0 and at t = t

So we can write as,

$$\cos\theta=\frac{\Delta v^2-v_i^{\,2}-v_f^{\,2}}{2v_iv_f}$$

$$\cos\theta=\frac{(5)^2-\left(\sqrt{5}\right)^2-\left(2\sqrt{5}\right)^2}{2\times\left(\sqrt{5}\right)\times\left(2\sqrt{5}\right)}$$

$$\cos\theta=\frac{25-5-20}{20}$$

$$\cos\theta=\frac{0}{20}$$

$$\cos\theta=0$$

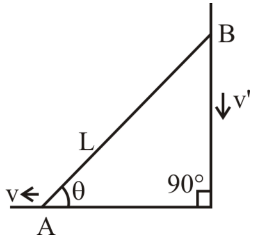
$$\cos\theta=\cos 90^{o}$$

$$\boxed{\theta=90^{o}}$$

So, the angle between initial and final velocity is 90°.

@apna_pdf

332. A thin uniform rod of length L is resting against a wall and the floor as shown in the figure. Its lower end A is pulled towards left with a constant velocity v. Then the downward velocity v' of the other end B when the rod makes an angle θ with the floor is

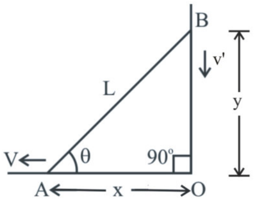


(a) v (b) v cos θ

(c) v sinθ (d) v cot θ

AP EAMCET (20.04.2019) Shift-II

Ans. (d) :



Let AO = x and OB = y

As we know,

$$\text{Velocity}\left(v_A\right)=\frac{dx}{dt}$$

And $$v_B=-\frac{dy}{dt}$$

Where –Ve sign denotes that y is decreasing. So from figure,

$$x^2+y^2=L^2 \qquad .....(i)$$

By differentiating equation (i) w.r.t 't'.

$$2x\cdot\frac{dx}{dt}+2y\frac{dy}{dt}=0$$

$$2x\,(V_A)+2y\,(-V_B)=0$$

or $$V_A\,.x=V_B\,.y$$

$$V_B=V_A\frac{x}{y}$$

Where $V_A=V$ and $V_B=V'$

$$\therefore \quad V'=\frac{x}{y}.V=\cot\theta.v$$

$$\boxed{V'=V\cot\theta}$$

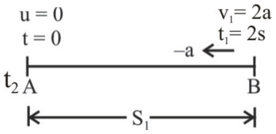
333. A body starting from rest at t = 0 moves along a straight line with a constant acceleration. At t = 2s, the body reverses its direction keeping the acceleration same. The body returns to the initial position at t = t_0, then t_0 is

(a) 4s (b) $(4+2\sqrt{2})$s

(c) $(2+2\sqrt{2})$s (d) $(4+4\sqrt{2})$s

AP EAMCET (20.04.2019) Shift-II

Ans. (b) : As per question,



From the equation of motion,

$$V_1=u+at_1$$
$$V_1=0+a\times2$$
$$V_1=2a$$
$$t_1=2\text{ sec}$$

Now, from the second equation of motion,

$$S_1=ut_1+\frac{1}{2}at_1^{\,2}=AB$$

$$S_1=0+\frac{1}{2}\times a\times2^2$$

$$S_1=2a$$

And for the reverse direction, a = – a

let time taken by body moves from B to A = t_2

Then, $t_0=t_1+t_2$

For BA using equation $s=ut+\frac{1}{2}at^2$

$$-s_1=v_1t_2-\frac{1}{2}at_2^{\,2}$$

$$-2a=2at_2-\frac{1}{2}at_2^{\,2}$$

$$t_2^{\,2}-4t_2-4=0$$

$$t_2=\frac{4\pm\sqrt{16-4\times(-4)}}{2}$$

$$t_2=\frac{4+4\sqrt{2}}{2}=2+2\sqrt{2}$$

So, $$t_0=t_1+t_2$$
$$=2+2+2\sqrt{2}$$
$$t_0=4+2\sqrt{2}$$

334. The velocity of an object moving in a straight line path is given as a function of time by *v* =*6 t – 3t*^{2}, where v is in ms^{-1}, *t* is in s. The average velocity of the object between, *t* = 0 and *t* = 2 is

(a) 0 (b) 3 ms^{-1}

(c) 2 ms^{-1} (d) 4 ms^{-1}

AP EAMCET (20.04.2019) Shift-1

Ans. (c) : Given, velocity equation, $v=6t-3t^2$

$$v=dx/dt$$

Here x is the displacement of the particle

$$dx=vdt$$

As we know

From equation, if displacement is x

$$\therefore \quad x=\int_0^2 v.dt=\int_0^2(6t-3t^2).dt$$

Where limit 0 to 2 is given in question so,

$$x=\int_0^2(6t-3t^2).dt=\left[\frac{6t^2}{2}\right]_0^2-\left[\frac{3t^3}{3}\right]_0^2$$

@apna_pdf

$$x = \left[3(2)^2 - 3(0)^2\right] - \left[(2)^3 - (0)^3\right]$$

$$x = 12 - 8$$

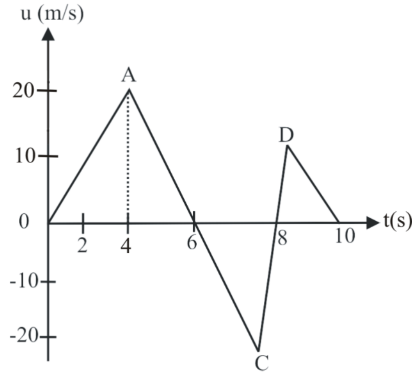
$$x = 4\text{m}$$

Average velocity $= \dfrac{\text{Total displacement}}{\text{Total time}}$

$$V_{avg} = \frac{4}{2} = 2 \text{ m/s}$$

Hence, the average velocity of the object between t = 0s to t = 2s is 2m/s.

335. The velocity time graph of a body moving in a straight line is shown in fig. Find the displacement and distance travelled by the body in 10 seconds.



(a) 50m, 90m,
(b) 5m, 9m
(c) 9m, 5m
(d) 90m, 50m

VITEEE-2019

Ans. (a) :

Displacement = Sum of all the areas with sign

$= (A_1) + (-A_2) + (A_3)$

Total displacement in 10 sec travelled by the body –

$$= \frac{1}{2} \times 6 \times 20 - \frac{1}{2} \times 2 \times 20 + \frac{1}{2} \times 2 \times 10$$

$= 60 - 20 + 10$

$= 50$ m

Distance = Sum of all the areas with sign

$= |A_1| + |-A_2| + |A_3|$

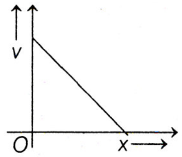
Total distance covered in 10 sec

$$= \left|\frac{1}{2} \times 6 \times 20\right| + \left|\frac{-1}{2} \times 2 \times 20\right| + \left|\frac{1}{2} \times 2 \times 10\right|$$

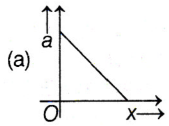
$= 60 + 20 + 10$

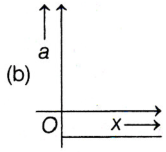
$= 90$ m

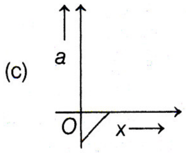
336. The given graph shows the variation of velocity v with position x for a particle moving along a straight line :

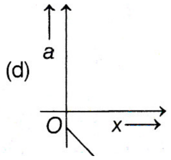


Which of the following graph shown the variation of acceleration a with position x ?





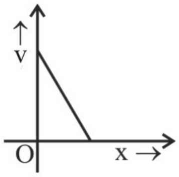




Karnataka CET-2019

Ans. (c) : According to velocity-position graph,

$v = -mx + v_0$ …….(1)



Where,

m = Slope of graph which is –ve

v_0 = Intercept of line which is +ve

$$a = \frac{dv}{dt} = -m\left(\frac{dx}{dt}\right) + \frac{d}{dt}(v_0)$$

$a = -mv + 0$

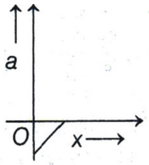
From equation (1)

$a = -m(-mx + v_0)$

$a = m^2x - mv_0$ …….(2)

Slope = +ve

Intercept = –ve



337. An object is moving with uniform acceleration *a*. Its initial velocity is *u* and after time *t* its velocity is *v*. The equation of its motion is *v* = *u* + *at*. The velocity (along y-axis) time (along the x-axis) graph shall be a straight line

(a) passing through origin
(b) with *x*-intercept *u*
(c) with y-intercept *u*
(d) with slope *u*

NDA (I) 2018

Ans. (c) : Given equation v = u + at

We know that equation of line

Y = mx + c

On comparing

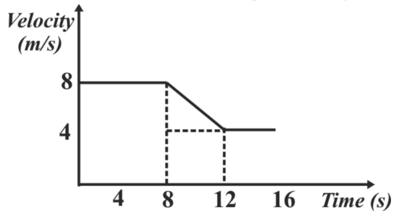
v = at + u

Where a = slope

u = Intercept with y axis

@apna_pdf

338. Consider the following velocity and time graph:



Which one of the following is the value of average acceleration from 8s to 12s?

(a) 8 m/s^2 (b) 12 m/s^2

(c) 2 m/s^2 (d) -1 m/s^2

NDA (II) 2018

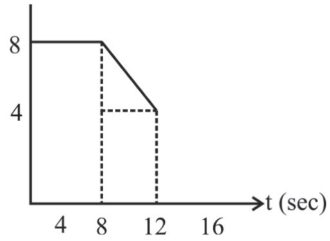
Ans. (d): given that,

$v_1 = 8$m/s

$t_1 = 8$ sec

$v_2 = 4$ m/sec

$t_2 = 12$ sec



Average acceleration

$$a = \frac{dv}{dt} = \frac{4-8}{12-8} = \frac{-4}{4}$$

$a = -1$ m/sec^2

339. The relation between time t and distance x for a moving particle is t = $\alpha x^2 + \beta x$, where α and β are constants. If v is the velocity at distance x, then the retardation of the particle is

(a) $2\alpha v^3$ (b) $2\beta v^3$

(c) $2\alpha\beta v^3$ (d) $2\beta^2 v^2$

AMU-2018

Ans. (a) : Given,

$t = \alpha x^2 + \beta x$

Differentiating w.r.t to time, we have

$$1 = 2\alpha x \frac{dx}{dt} + \beta \frac{dx}{dt} \quad ..(i)$$

We know,

$1 = 2\alpha x\, v + \beta v$

$v(2\alpha x + \beta) = 1 \quad \ldots(ii)$

Again differentiating equation (i) w.r.t to time, we have

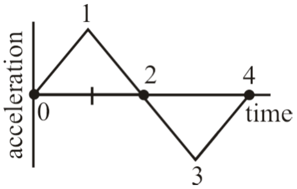
$$0 = 2\alpha x \frac{d^2x}{dt^2} + \frac{\beta d^2x}{dt^2} + 2\alpha\left(\frac{dx}{dt}\right)^2$$

$$0 = (2\alpha x + \beta)\, a + 2\alpha v^2 \qquad \left(\because \frac{d^2x}{dt^2} = a\right)$$

$a = -\,2\alpha v^3$ m/sec^2

$\therefore$ Retardation = $2\alpha v^3$ m/sec^2

340. Acceleration-time graph of a body moving in a straight line is as shown. The body started its motion from rest.



At which point is the body moving with the largest speed?

(a) 1 (b) 2

(c) 3 (d) 4

AMU-2018

Ans. (b) : According the acceleration - time graph, speed = area under acceleration - time graph.

As given in the graph area is maximum for point 0 to 2.

Therefore,

At point 2, the body moves with the largest speed.

341. A body covers 2/5th of the total distance with speed v_1 and 3/5th with v_2. The average speed of the body will be–

(a) $\dfrac{5v_1v_2}{3v_1+2v_2}$ (b) $\dfrac{v_1+v_2}{2}$

(c) $\dfrac{1}{2}\sqrt{v_1v_2}$ (d) $\dfrac{2v_1v_2}{v_1+v_2}$

BCECE-2018

Ans. (a) : Let the total distance is x, then we have

$$t_1 = \frac{2}{5}\frac{x}{v_1} \text{ and } t_2 = \frac{3}{5}\frac{x}{v_2}$$

Since average speed,

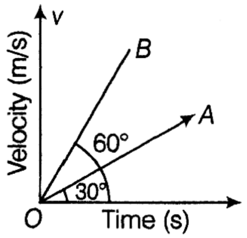
$$v_{av} = \frac{\text{Total distance}}{\text{Total time}} = \frac{x}{t_1 + t_2}$$

$$= \frac{x}{\frac{2x}{5v_1} + \frac{3x}{5v_2}} = \frac{x}{\frac{10xv_2 + 15xv_1}{25v_1v_2}}$$

$$= \frac{x}{\frac{5x(2v_2+3v_1)}{25v_1v_2}}$$

$$\therefore \quad = v_{av} = \frac{5v_1v_2}{3v_1 + 2v_2}$$

342. The velocity-time graph of two bodies A and B are shown below.



@apna_pdf

Then, the ratio of their acceleration a_A/a_b will be–

(a) $\sqrt{3}:1$
(b) $1:\sqrt{3}$
(c) 3:1
(d) 1:3

BCECE-2018

Ans. (d) : Acceleration = Slope of velocity – time graph

Thus, $\frac{a_A}{a_B} = \frac{\text{Slope of } v-t \text{ graph for A}}{\text{Slope of } v-t \text{ graph for B}}$

$$= \frac{\tan 30°}{\tan 60°}$$

$$\frac{a_A}{a_B} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3} \Rightarrow a_A : a_B = 1:3$$

343. A particle experiences constant acceleration for 20 seconds after starting from rest. If it travels a distance s_1 in the first 10 seconds and distance s_2 in the next 10 seconds, then

(a) $s_2 = s_1$
(b) $s_2 = 2\ s_1$
(c) $s_2 = 3\ s_1$
(d) $s_2 = 4\ s_1$

AIIMS-27.05.2018(M)

Ans. (c) : Let a be the constant acceleration of the particle.

From the second equation of motion-

$$s = ut + \frac{1}{2}at^2$$

or $\quad s_1 = 0 + \frac{1}{2} \times a \times (10)^2 = 50a$

S_2 = (Total distance covered in 20 sec) – (total distance covered in first 10 second)

$$S_2 = S_{20} - S_{10}$$

and $\quad s_2 = \left[0 + \frac{1}{2} \times a \times (20)^2\right] - 50a = 150a$

$\therefore \quad s_2 = 3s_1$

344. A bus is moving with a velocity of 10 ms^{-1} on a straight road. A scootorist wishes to overtake the bus in one minute. If the bus is at a distance of 1.2 km ahead, then the velocity with which he has to chase the bus is

(a) 20 ms^{-1}
(b) 25 ms^{-1}
(c) 60 ms^{-1}
(d) 30 ms^{-1}

AIIMS-26.05.2018(M)

Ans. (d) : Given,

t = 60sec, Distance = 1.2 km = 1200m

v_{bus} = 10m/s

The relative speed with respect to the bus is –

$$\mathbf{v} = \frac{d}{t} = \frac{1200}{60} = 20\text{m/s}$$

The scooter and the bus are moving along the same direction, so-

speed (v) $= v_{scooter} - v_{bus}$

$20 = v_{scooter} - 10$

$v_{scooter} = 30$ m/s

345. The motion of a particle along a straight line is described by equation: $x = 8 + 12t - t^3$ where x is in meter and t is second. The retardation of the particle when its velocity becomes zero is:

(a) 24 ms^{-2}
(b) zero
(c) 6 ms^{-2}
(d) 12 ms^{-2}

AIIMS-26.05.2018(E)

Ans. (d): Given,

$$x = 8 + 12t - t^3$$

$$v = \frac{dx}{dt} = 12 - 3t^2 \qquad \text{.......(i)}$$

$$a = \frac{dv}{dt} = -6t \qquad \text{.......(ii)}$$

Putting v = 0 in equ. (i)

$3t^2 = 12$

t = 2 sec

From equ. (ii) $\quad a = -6 \times 2 = -12\ m/s^2$

Retardation = 12 m/s^2

346. Assertion : A body may be accelerated even when it is moving uniformly.

Reason: When direction of motion of the body is changing, the body must have acceleration.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(M)

Ans. (d) : The uniform motion of a body means that the body is moving with constant velocity, but if the direction of motion is changing (such as in uniform circular motion), its velocity changes and thus acceleration is produced in uniform motion.

347. Assertion : The position-time graph of a uniform motion in one dimension of a body can have negative slope.

Reason: When the speed of body decreases with time, the position-time graph of the moving body has negative slope.

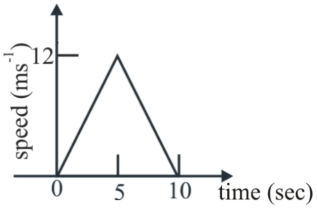
(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-27.05.2018(M)

Ans. (c) : The negative slope of position-time graph represent that the body is moving towards the negative direction and if the slope of the graph decreases with time. Then, it represents the decrease in speed i.e retardation in motion.

@apna_pdf

348. **The speed time graph of a particle moving along a fixed direction is shown. The distance travelled by the particle in 10 s is**



(a) 20 m (b) 30 m
(c) 40 m (d) 60 m

COMEDK 2018

Ans. (d): Total distance travelled by the particle = Area under the v-t graph

$$s = \frac{1}{2} \times (10-0) \times (12-0)$$

$$s = \frac{1}{2} \times 10 \times 12$$

$$s = 60 \text{ m}$$

349. **Consider a particle moving along the positive direction of X-axis. The velocity of the particle is given by $v = \alpha\sqrt{x}$ (α is a positive constant). At time t = 0, if the particle is located at $x = 0$, the time dependence of the velocity and the acceleration of the particle are respectively**

(a) $\frac{\alpha^2}{2}t \text{ and } \frac{\alpha^2}{2}$ (b) $\alpha^2 t$ and α^2

(c) $\frac{\alpha}{2}t \text{ and } \frac{\alpha}{2}$ (d) $\frac{\alpha^2}{4}t \text{ and } \frac{\alpha^2}{4}$

TS-EAMCET-04.05.2018, Shift-1

Ans. (a) : Given that,
Relation between velocity (v) and displacement (x) is

$$v = \alpha\sqrt{x}$$

$$\frac{dx}{dt} = \alpha\sqrt{x} \qquad \left(\sqrt{x} = dt\right)$$

$$\frac{dx}{\sqrt{x}} = \alpha dt$$

$$\int \frac{dx}{\sqrt{x}} = \alpha \int dt$$

$$\frac{x^{-\frac{1}{2}+1}}{-\frac{1}{2}+1} = \alpha t + c$$

Since at t = 0, x = 0, we get c = 0

So, $2\sqrt{x} = \alpha t \Rightarrow 4x = \alpha^2 t^2$

$$x = \frac{1}{4}\alpha^2 . t^2$$

Differentiating with respect to t, we get –

$$v = \frac{dx}{dt} = \frac{1}{4}\alpha^2\left(2t^{2-1}\right)$$

$$\boxed{v = \frac{1}{2}\alpha^2 t}$$

$$\text{Acceleration (a)} = \frac{dv}{dt} = \frac{1}{2}\alpha^2$$

$$\boxed{a = \frac{\alpha^2}{2}}$$

350. **An object moves in a straight line with deceleration whose magnitude varies with velocity as $3v^{2/3}$. If at an initial point, the velocity is 8 m/s, then the distance travelled by the object before it stops is**

(a) 2 m (b) 4 m
(c) 6 m (d) 8 m

TS-EAMCET-04.05.2018, Shift-2

Ans. (b) : Given that, deceleration (a) $= -3v^{2/3}$

initial velocity (u) = 0

v = 0 s = ?

We know, $a = \frac{dv}{dt} = -3v^{2/3}$

$$\frac{dv}{dx}\frac{dx}{dt} = -3v^{2/3}$$

$$\frac{dv}{dx}v = -3v^{2/3}$$

$$\frac{dv}{dx} = -3v^{2/3-1}$$

$$\frac{dv}{dx} = -3v^{-\frac{1}{3}}$$

Now integrating both side

$$-\int_8^0 v^{\frac{1}{3}} dv = \int_0^x 3dx$$

$$-\left[\frac{v^{\frac{1}{3}+1}}{\frac{1}{3}+1}\right]_8^0 = 3[x]_0^x$$

$$-\frac{3}{4}\left[v^{\frac{4}{3}}\right]_8^0 = 3x$$

3x = 12

x = 4

351. **A bullet enters in a piece of wood with velocity v_0 and the resistive force acting on the bullet in the wood is proportional to $v^{\frac{1}{3}}$. If the total distance travelled by the bullet is proportional to $(v_0)^\beta$, then the value of β is**

(a) $\frac{2}{3}$ (b) $\frac{5}{3}$

(c) $\frac{4}{3}$ (d) $-\frac{1}{3}$

TS-EAMCET-05.05.2018, Shift-2

@apna_pdf

Ans. (b) : Given,

Resistive force $(F_r) \propto v^{\frac{1}{3}}$

$F_r = k\,v^{\frac{1}{3}} \Rightarrow -m.a = k\,v_0^{\frac{1}{3}}$

$a = \dfrac{-k}{m} v_0^{\frac{1}{3}}$

$\because \quad v^2 = u^2 + 2as$

$2as = v^2 - u^2$

$2 \times \dfrac{-k}{m} v_0^{\frac{1}{3}}.s = 0 - v_0^2$

$s = \dfrac{m}{2k} v_0^{\left(2-\frac{1}{3}\right)} \Rightarrow s = \dfrac{m}{2k} v_0^{\frac{5}{3}}$

$s \propto v_0^{\frac{5}{3}}$ ……(i)

If the total distance,

$s \propto v_0^{\beta}$

comparing equation (i), then β value 5/3.

352. What does the speedometer of a vehicle read/measure?

(a) Average speed

(b) Average velocity

(c) Instantaneous speed

(d) Instantaneous velocity

JCECE-2018

Ans. (c) : Speedometer is device that measures the speed of vehicle at any instant of time i.e. measure instantaneous speed.

353. Assertion (A) : The angle between acceleration and velocity of a body is one-dimensional motion is always zero.

Reason (R) : One-dimensional motion is along a straight line.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

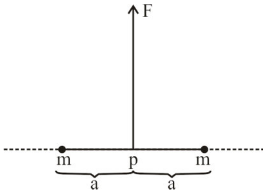
(d) A is false but R is true

AP EAMCET (22.04.2018) Shift-II

Ans. (d) : For one –dimentional, motion is always along the strength line. i.e. the angle between acceleration and velocity may be 180° or 0°. So reason is correct but assertion is not correct as during acceleration.

Hence, option (d) is correct.

354. As shown in the figure, two particle each of mass m tied at the ends of a light string of length 2a are kept on a frictionless horizontal surface. When the mid-point (P) of the string is pulled vertically upwards with a small but constant force F, the particles move towards each other on the surface. Magnitude of acceleration each particle, when the separation between them becomes 2x is



(a) $\dfrac{F}{2m}\dfrac{a}{\sqrt{a^2-x^2}}$ (b) $\dfrac{F}{2m}\dfrac{x}{\sqrt{a^2-x^2}}$

(c) $\dfrac{F}{2m}\dfrac{x}{a}$ (d) $\dfrac{F}{2m}\dfrac{\sqrt{a^2-x^2}}{x}$

AP EAMCET (23.04.2018) Shift-1

Ans. (b) : Given that,

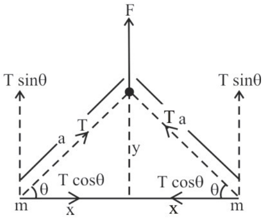
Length of string = 2a

Resolving the forces along vertical and horizontal axis force along the vertical axis

2T sinθ = F--------(i)

Force along the horizontal axis

T cos θ = ma --------(ii)



On dividing equation (i) by equation (ii)

We get,

$$2\tan\theta = \frac{F}{ma}$$

Or

$$a = \frac{F}{2m\tan\theta} = \frac{F}{2m\left(\dfrac{\sqrt{a^2-x^2}}{x}\right)} \quad \left[\because \tan\theta = \frac{\sqrt{a^2-x^2}}{x}\right]$$

$$\boxed{a = \frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}}$$

355. A body is projected horizontally from the top of a tower of height 180 m with a velocity of 20 ms^{-1}. If acceleration due to gravity is 10 ms^{-2}, then match the following.

	List-I	List-II	
A	Velocity of the body after 1 second (in ms^{-1})	I	5
B	Horizontal displacement of the body after 1 second (in metres)	II	20
C	Vertical displacement of the body after 1 second (in metres)	III	10
D	Vertical velocity of the body after 1 second (in ms^{-1})	IV	22.4

	A	B	C	D
(a)	IV	II	III	I
(b)	I	II	III	IV
(c)	IV	II	I	III
(d)	II	IV	I	III

AP EAMCET (23.04.2018) Shift-1

@apna_pdf

Ans. (d) : Given that,
Initial velocity of horizontal component $u_x = 20$ m
Initial velocity along the vertical component $u_y = 0$

Acceleration due to gravity
$a_g = 10 \text{ m/s}^{-2}$

Horizontal velocity after 1s
$v_x = u_x + a_x t$
$v_x = 20 + 0$
$= 20 \text{ m/s}^{-2}$

Vertical velocity after 1 second
$v_y = u_y + a_y t$
$= 0 + 10 \times 1 = 10 \text{m/s}$

Horizontal displacement of the body after 1 second.

$$s_x = u_x t + \frac{1}{2} a_x t^2$$
$$= 20 \times 1 + 0 = 20\text{m}$$

Vertical displacement of the body after 1 second

$$s_y = u_y t + \frac{1}{2} a_y t^2$$
$$= 0 + \frac{1}{2} \times 10 \times (1)^2 = 5 \text{ m}$$

Velocity of the body after 1 second

$$v = \sqrt{v_x^2 + v_y^2}$$
$$= \sqrt{(20)^2 + (10)^2} = \sqrt{400+100}$$
$$= \sqrt{500}$$
$$= 22.36 = 22.4 \text{m/s}$$
$$\boxed{v = 22.4 \text{ m/s}}$$

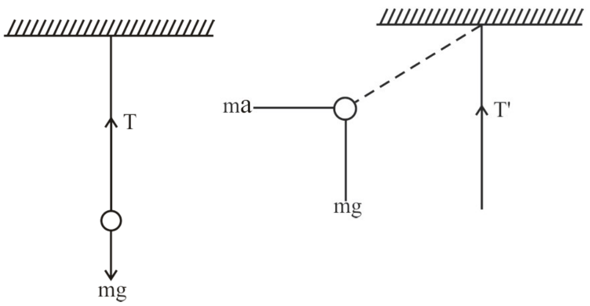
356. A solid ball is suspended from the ceiling of a motor car through a light string. A transverse pulse travels at the speed 60 cms^{-1} on the string, when the car is at rest. When the car accelerates on a horizontal road, then speed of the pulse is 66 cms^{-1}. The acceleration of the car is nearly (g = 10 ms^{-2})

(a) 4.3 ms^{-2} (b) 2.9 ms^{-2}
(c) 6.8 ms^{-2} (d) 5.5 ms^{-2}

AP EAMCET (22.04.2018) Shift-1

Ans. (c) : Given data,

$v_1 = 60 \text{ cm/s}$, $v_2 = 66 \text{ cm/s}$



$$v_1 = \sqrt{\frac{mg}{\mu}} \quad \ldots\ldots\text{(i)}$$

$$v_2 = \sqrt{\frac{T'}{\mu}}$$

$$v_2 = \sqrt{\frac{m\left(a^2+g^2\right)^{\frac{1}{2}}}{\mu}} \quad \ldots\ldots\text{(ii)}$$

From equation (i) and (ii),

$$\frac{v_2}{v_1} = \frac{\sqrt{\sqrt{(ma)^2+(mg)^2}}}{\sqrt{mg}}$$

$$\frac{v_2^2}{v_1^2} = \frac{\sqrt{(ma)^2+(mg)^2}}{mg}$$

$$\left(\frac{66}{60}\right)^2 = \frac{\sqrt{a^2+g^2}}{g}$$

$$\left(\frac{11}{10}\right)^2 = \frac{\sqrt{a^2+g^2}}{g}$$

$$\frac{121}{100} g = \sqrt{a^2+g^2}$$

$$a^2 + g^2 = (1.21)^2 g^2$$

$$a^2 = 146.41 - 100$$

$$a^2 = 46.41$$

$$a = 6.8 \text{ m/s}^2$$

357. A body of mass 2 kg thrown vertically from the ground with a velocity of 8 ms^{-1} reaches a maximum height 3 m. The work done by the air resistance is (acceleration due to gravity = 10 ms^{-2})

(a) 4J (b) 60J
(c) 64J (d) 8J

AP EAMCET (22.04.2018) Shift-1

Ans. (a) : Given that,
Mass of body (m) = 2 kg
Velocity (v) = 8 ms^{-1}
Height (h) = 3m
We know kinetic energy,

$$\text{K.E.} = \frac{1}{2} mv^2$$
$$= \frac{1}{2} \times 2 \times 8^2$$
$$\boxed{\text{K.E.} = 64\text{J}}$$

P.E. = mgh
= 2 × 10 × 3

$$\boxed{\text{P.E.} = 60\text{J}}$$

Work done by the air resistance,
W = K.E. – P.E.
W = 64 – 60

$$\boxed{W = 4\text{J}}$$

@apna_pdf

358. A stone is released from an aeroplane which is rising with upward acceleration 5 m/s^2. Here, g = 10 m/s^2. Two seconds after the release, separation between stone and aeroplane will be

(a) 10 m (b) 20 m
(c) 30 m (d) 25 m

UPSEE - 2018

Ans. (c) : Given, acceleration (a) = 5 m/sec^2

and g = 10 m/s^2

time (t) = 2 s

Since, the initial velocity of both stone and aeroplane is zero.

We know, $s = ut + \frac{1}{2}at^2$

Hence, distance travelled by aeorplane = $\frac{1}{2} \times 5 \times 2^2$

= 10 m

and distance travelled by stone = $\frac{1}{2} \times 10 \times 2^2$

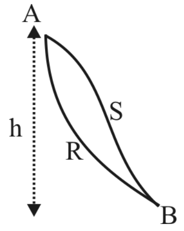
= 20m

Therefore, the distance between stone and aeroplane

= 10 + 20

= 30m.

359. Two childrens Ramesh (on path ARB) and Sohan (on path ASB), travel down slides of identical height *h* but different shapes as shown in the figure. Assuming, they start down the frictionless slides at the same time with zero initial velocity, which of the following statement is true?



(a) Ramesh reaches the bottom first with the same average velocity as Sohan.
(b) Ramesh reaches the bottom first with a larger average acceleration than Sohan.
(c) Ramesh reaches the bottom first with the same average acceleration as Sohan.
(d) They reach the bottom at same time with the same average acceleration.

UPSEE - 2018

Ans. (d) :

We know that, acceleration due to gravity $g = \frac{Gm}{R^2}$ so,

g is independent of the shape of the slide as height is same i.e. h and acceleration due to gravity of Ramesh and Sohan also same.

∴ Both reach the bottom at same time

360. The distance travelled by an object along a straight line in time t is given by s = 3 – 4t + 5t^2, the initial velocity of the object is

(a) 3 unit (b) –3 unit
(c) 4 unit (d) – 4 unit

COMEDK 2018

Ans. (d) : Given,

Distance (s) = 3 – 4t + 5t^2

Velocity (v) = $\frac{ds}{dt} = -4 + 10t$

$= -4 + 10 \times 0$

Initial velocity (u) = $\left.\frac{ds}{dt}\right|_{t=0} = -4\,\text{unit}$

361. A cart of mass 150 kg is pulled horizontally on a frictionless surface with force 10 N. If 100 g/s sand is being dropped in the cart vertically then find the speed of the system when cart has 100 kg sand in it.

(a) 10 m/s (b) 20 m/s
(c) 40 m/s (d) 50 m/s

AIIMS-26.05.2018(E)

Ans. (c) : Given,

m = 150kg,
F = 10N,
μ = 100g/sec = 100 × 10^{-3} kg/sec
m = 100 kg

$F - \mu v = \frac{mdv}{dt}$

$F - \mu v = (m_0 + \mu t)\frac{dv}{dt}$ $\begin{Bmatrix}\text{Here} \\ m = m_0 + \mu t\end{Bmatrix}$

$\frac{dt}{m_0 + \mu t} = \frac{dv}{F - \mu v}$

Integrating both side,

$$\int_0^t \frac{dt}{m_0 + \mu t} = \int_0^v \frac{dv}{F - \mu v}$$

$$\frac{1}{m_0}\int_0^t \frac{dt}{1 + \frac{\mu t}{m_0}} = \frac{1}{F}\int_0^v \frac{dv}{1 - \frac{\mu v}{F}}$$

$$\ln\left|1 + \frac{\mu t}{m_0}\right| = -\ln\left|1 - \frac{\mu v}{F}\right|$$

$$1 + \frac{\mu t}{m_0} = \frac{1}{1 - \frac{\mu v}{F}}$$

Now, velocity (v) = $\frac{Ft}{m_0 + \mu t}$ ……(i)

$t = \frac{m}{\mu} = 1000\,\text{sec}$

From equation (i)

$$v = \frac{10 \times 1000}{150 + \left(100 \times 10^{-3}\right) \times 1000}$$

$$v = \frac{10 \times 1000}{150 + 100} = 10000/250$$

v = 40 m/s

@apna_pdf

362. The position vector of the particle is $r(t)=a\cos\omega t\,\hat{i} + a\sin\omega t\,\hat{j}$, where a and ω are real constants of suitable dimensions. The acceleration is:

(a) Perpendicular to the velocity
(b) Parallel to the velocity
(c) Directed away from the origin
(d) Perpendicular to the position vector
(e) Always along the direction of $\hat{i}$

Kerala CEE -2018

Ans. (d) : Given

$$r(t) = a\cos\omega t\,\hat{i} + a\sin\omega t\,\hat{j}$$

∴ velocity vector

$$\vec{v} = \frac{d\vec{r}(t)}{dt} = a(-\omega\sin\omega t\,\hat{i} + \omega\cos\omega t\hat{j})$$

$$\vec{a} = \frac{d\vec{v}}{dt} = \omega a\{-\omega\cos\omega t\,\hat{i} - \omega\sin\omega t\hat{j}\}$$

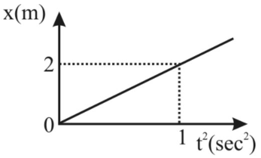
$$= -\omega^2 a\left\{\cos\omega t\hat{i} + \sin\omega t\hat{j}\right\} = -\omega^2.\vec{r}$$

$$\hat{a}.\hat{v} = -\omega^2 a^2\{-\sin\omega t\cos\omega t + \sin\omega t\cos\omega t\}$$

$$= 0$$

So, $\hat{a}$ and $\hat{v}$ are perpendicular to each other.

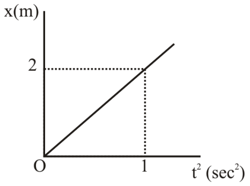
363. Displacement x versus t^2 graph is shown for a particle. The acceleration of the particle is



(a) 4 m/s^2
(b) 8 m/s^2
(c) zero
(d) 2m/s^2

UPSEE - 2017

Ans. (a) :



By given graph

$x = \text{slope}(t^2)$

$$x = \frac{2-0}{1-0}\times t^2$$

$x = 2t^2$

Differentiating x w.r.t 't' we get velocity

$$\frac{dx}{dt} = 4t$$

Again differential $\frac{dx}{dt}$ w.r.t 't' we get acceleration

$$\frac{d^2x}{dt^2} = 4$$

Which is the value of acceleration

i.e. $\boxed{a = 4m/s^2}$

364. The velocity of a particle is zero at time t = 2, then

(a) displacement must be zero in the interval t = 0 to t = 2
(b) acceleration may be zero at t = 2
(c) velocity must be zero for t > 2
(d) acceleration must be zero at t = 2

UPSEE - 2017

Ans. (d) : Let us consider an example in which a particle is moving on horizontal plane and it comes to rest permanently at t = 1, then this is one of the special case in which acceleration of particle is zero at t = 2

$$a = \frac{dv}{dt} = 0 \qquad (\text{at } t = 2)$$

365. A body moves along a straight line with acceleration 3 ms^{-2} for 2s and then with acceleration 4 ms^{-2} for 3s. What is his average acceleration?

(a) 3.4 ms^{-2}
(b) 3.5 ms^{-2}
(c) 3.6 ms^{-2}
(d) 3.7 ms^{-2}

JCECE-2017

Ans. (c) : Given,

$a_1 = 3m/s^2$, $t_1 = 2s$
$a_2 = 4m/s^2$, $t_2 = 3s$

$$\text{Average acceleration } (a_{avg}) = \frac{a_1t_1 + a_2t_2}{t_1 + t_2}$$

$$a_{avg} = \frac{3\times2 + 4\times3}{2+3} = 3.6m/s^2$$

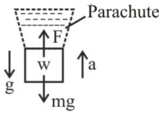
366. A packet of weight 'W' dropped from a parachute strikes the ground and comes to rest with retardation equal to twice the acceleration due to gravity. The force exerted on the ground is

(a) W (b) 2W (c) 3W (d) 4W

AP EAMCET-25.04.2017, Shift-I

Ans. (c) : Given,

packet weight = w, Retardation (a) = 2g



w = mg

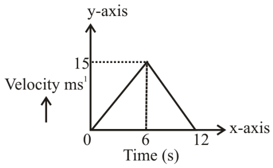
From figure

F– w = ma

$$F - w = \frac{w}{g}\times 2g \Rightarrow F - w = 2w$$

F = 3w

367. The velocity and time graph for a particle moving in a straight line is shown in the figure. Then, the average velocity between t = 4 s and t = 6 s is_____



@apna_pdf

(a) $10.5\ ms^{-1}$ (b) $12.5\ ms^{-1}$
(c) $7.5\ ms^{-1}$ (d) $9.5\ ms^{-1}$

AP EAMCET-25.04.2017, Shift-I

Ans. (b) : Given,
time interval, $t = t_2 - t_1 = 2sec$
$t_1 = 4$ sec, $t_2 = 6$ sec
slop of v-t graph, [v = velocity, t = time]
We know that,

Acceleration, $a = \tan\theta = \frac{15}{6} = \frac{5}{2} ms^{-2}$

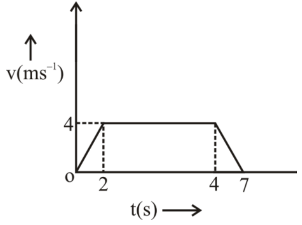
initial u = 0
velocity at $t_1 = 4$ sec
then, $v = u + at$

$$v = 0 + \frac{5}{2} \times 4$$

$v_1 = 5 \times 2 = 10$ m/sec (given)
So, average

$$\frac{v_1 + v_2}{2} = \frac{10+15}{2} = \frac{25}{2} = 12.5 = 12.5 m/sec$$

368. The variation of velocity (v) of a particle with time (t) is shown in the figure. The average velocity of the particle during its motion is



(a) $\frac{20}{7} ms^{-1}$ (b) $\frac{18}{7} ms^{-1}$

(c) $\frac{36}{7} ms^{-1}$ (d) $\frac{12}{7} ms^{-1}$

AP EAMCET-28.04.2017, Shift-II

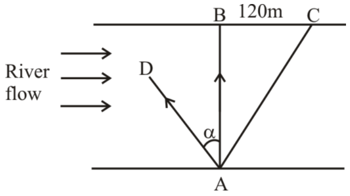
Ans. (b) : $V_{Avg} = \frac{\text{Total distance}}{\text{total time}}$

Total distance = S

$S_1 = \frac{1}{2} \times 2 \times 6 = 6m$
$S_2 = 6 \times 2 = 12$
$S = S_1 + S_2$
$= 6 + 12 = 18m$

$V_{Avg} = \frac{18}{7}$ m/sec .

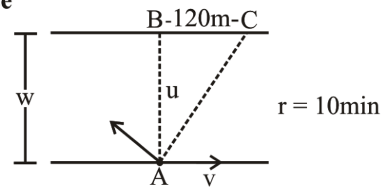
369. If a boat moves perpendicular to the bank of a river from a point A, it reaches a point C which is at 120 m down the stream form a point B on the opposite bank in 10 minutes as shown in the figure. If the boat moves with the same velocity at an angle α along AD unstream it reaches the point B in 12.5 minutes. The width of the river and the angle α respectively are __________.
(Line AB is perpendicular to the banks of the river).



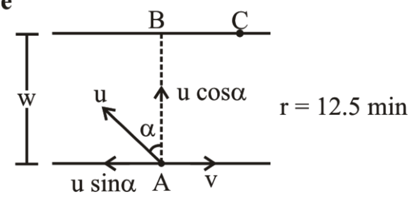
(a) 100 m, $\sin^{-1}(0.8)$ (b) 200 m, $\cos^{-1}(0.8)$
(c) 300 m, $\tan^{-1}(0.6)$ (d) 300 m, $\cos^{-1}(0.6)$

AP EAMCET-28.04.2017, Shift-I

Ans. (b) :
I. Case



II. Case



In Case-I

$$u = \frac{w}{10 \times 60}$$

$$u = \frac{2}{600} \qquad w = \text{width}$$

$$v = \frac{120}{10 \times 60} = 0.2 \text{ m/s}$$

So, Case-II

$$u\cos\alpha = \frac{w}{12.5 \times 60}$$

$$u\cos\alpha = \frac{w}{750} \qquad ...(i)$$

$\Rightarrow$ $v = u\sin\alpha$

$$\frac{1}{5} = u\sin\alpha$$

$$\therefore \frac{u\sin\alpha}{u\cos\alpha} = \frac{1/5}{w/750}$$

$$\tan\alpha = \frac{750}{5w} \qquad \sin\alpha = \frac{1}{5w}$$

So,

$$u\left[\sqrt{\frac{25u^2-1}{5u}}\right] = \frac{w}{750}$$

$$\frac{25u^2-1}{25} = \frac{w^2}{750 \times 750} \qquad ...(ii)$$

From eq^n (i) and (ii)

$$= \frac{25u^2-1}{25} = \frac{(600u)^2}{750 \times 750}$$

@apna_pdf

$= \frac{25u^2 - 1}{25} = \frac{600 \times 600 \times u^2}{750 \times 750}$

$= 25\ u^2 - 1 = 16u^2$

$= 9u^2 = 1$

$= u = \frac{1}{3}$ m/s

So, $w = 600\ u = 600 \times \frac{1}{3} = 200$

$\tan\alpha = \frac{750}{5 \times 200}$ $\quad \tan\alpha = \frac{750}{1000}$

$\tan\alpha = \frac{3}{4}$ $\alpha = \tan^{-1}\frac{3}{4} = 37^o$

According to Pythagoras

$\cos\alpha = \frac{4}{5}$

Hence, w = 200 m

$\cos\alpha = \frac{4}{5}$ $\quad \cos^{-1}\alpha = \frac{4}{5}$ or 0.8

370. Two trains P and Q each of length 400m are moving along parallel tracks, in the same direction with a same uniform speed of 20 ms^{-1}. Driver of train decides to overtake train Q and decelerates his train by 1 ms^{-2}. If the train P crosses the train Q in 50 s, then the initial distance between the two trains was

(a) 450 m (b) 800 m
(c) 540 m (d) 425 m

AP EAMCET-28.04.2017, Shift-I

Ans. (a) : Assume the initial distance between both trains be x. Displacement travelled by Train P in 50s, According the motion third law

Given that

$$\begin{bmatrix} u = 20\ m/s \\ t = 50s \\ a = 1\ m/s^2 \end{bmatrix}$$

$s = ut + \frac{1}{2}at^2$

$s_P = 20 \times 50 + \frac{1}{2} \times 1 \times 50^2 \quad = 1000 + 1250$

$s_P = 2250$ m

train Q in f = 50s

$s_Q = ut = 20 \times 50$

$s_Q = 1000$m

Now,

$S_P - S_Q = 2250 - 1000$

$= 1250$ m

So, initial distance between both trains was,

$x + 800 = 1250$

$x = 1250 - 800 = 450$ m

371. The speed of a car travelling on a straight road is listed below at successive intervals of 1s

Time (s)	**0**	**1**	**2**	**3**	**4**
Speed (m/s)	**0**	**2**	**4**	**6**	**8**

Which of the following is/are correct.

The car travels

1. with a uniform acceleration of 2 m/s^2

2. 16 m in 4 s.

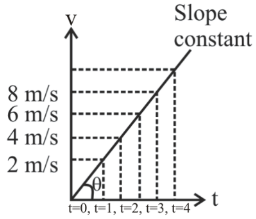
3. with an average speed of 4 m/s.

Select the correct answer using the code given below:

(a) 1, 2 and 3 (b) 2 and 3 only
(c) 1 and 2 only (d) 1 only

NDA (I) 2017

Ans. (a):



We know that $(a) = \frac{dv}{dt}$

I. $a = \left(\frac{dv}{dt}\right)$slope

a = constant

$a = \frac{dv}{dt} = \frac{8-0}{4-0} = 2m/sec^2$

$a = 2m/sec^2$

II. $v = \frac{dx}{dt}$

$\int dx = \int v.dt$

Area between v-t when t = 4 second

$x = \frac{1}{2} \times 4 \times 8$

III. Average speed x = 16 m

$\frac{\text{total distnace}}{\text{total time}} = \frac{16}{4} = 4\,m/sec$

372. A body of mass 10 kg is being acted upon by a force of 3t^2 N and an opposing constant force of 30 N. The initial speed is 10 ms^{-1}. The velocity of the body after 5 seconds is

(a) 12.5 ms^{-1} (b) 7.5 ms^{-1}
(c) 5 ms^{-1} (d) 2.5 ms^{-1}

AP EAMCET-28.04.2017, Shift-II

Ans. (b) : Net Force on the body,

$F_{net} = 3t^2 - 30$

Acceleration, $a = \frac{F}{m} = \frac{3t^2 - 30}{10}$ $\quad$ {given, m = 10kg}

$a = 0.3t^2 - 3$

@apna_pdf

We know that,

$$a = \frac{dv}{dt}$$

So, $dv = a\,dt$

$$\frac{dv}{dt} = 0.3t^2 - 3$$

$$dv = 0.3t^2.\,dt - 3dt$$

$$\int_{10}^{V} dv = 0.3\int_0^5 t^2.\,dt - 3\int_0^5 dt$$

$$[v]_{10}^{v} = 0.3 \times \left[\frac{t^3}{3}\right]_0^5 - 3[t]_0^5$$

$$(v-10) = 0.3 \times \left(\frac{5^3}{3}\right) - 3(5)$$

$$(v-10) = 0.3 \times \left(\frac{125}{3}\right) - 3(5)$$

$$v - 10 = 12.5 - 15$$

$$v = 22.5 - 15$$

$$v = 7.5\text{ms}^{-1}$$

373. A car moving with a velocity of 20 ms^{-1} stopped at a distance of 40 m. If the same car is travelling at double the velocity, the distance travelled by it for same retardation is :

(a) 320 m (b) 1280 m
(c) 160 m (d) 640 m

Karnataka CET-2017

Ans. (c) : Given that, velocity of car (u) = 20m/s
Distance (s) = 40 m

From Newton third equation–

$$v^2 = u^2 - 2as$$

$$v^2 - u^2 = -2as$$

$$(0)^2 - (20)^2 = -2 \times a \times 40$$

$$a = \frac{400}{2 \times 40} = 5m/s^2$$

In the second condition, the velocity u' = 2u

From Newton's third equation–

$$(0)^2 - (2u)^2 = -2 \times 5 \times s$$

$$s = \frac{(2u)^2}{2 \times 5} = \frac{4 \times 20 \times 20}{2 \times 5}$$

$$s = 160m$$

374. The motion of a particle is represented by the equation $s = 8t^3 - 2t^2 + 6t + 7$. Find the velocity of the particle at the end of 2 seconds in m s^{-1}.

(a) 108 (b) 57
(c) 94 (d) 41

J&K-CET-2017

Ans. (c) : Given,

$$s = 8t^3 - 2t^2 + 6t + 7$$

$$\text{Velocity (v)} = \frac{ds}{dt} = 24t^2 - 4t + 6$$

$$v_{(t=2)} = 24 \times 4 - 4 \times 2 + 6$$

$$= 94m/s$$

375. The displacement x of a particle varies with time t as $x = ae^{\alpha t} + be^{-\beta t}$ where a, b, α, β are positive constants. The velocity of the particle will

(a) go on decreasing with time
(b) be independent of α and β
(c) drop to zero when α = β
(d) go on increasing with time

CG PET- 2017

Ans. (d) : Given

$$x = ae^{\alpha t} + be^{-\beta t}$$

$$\frac{dx}{dt} = a\alpha e^{\alpha t} - b\beta e^{-\beta t}$$

by differentiating w.r.t time.

Here α and β are positive constant

Now, by differentiating again, we get,

$$a = \frac{dv}{dt} = a\alpha^2 e^{\alpha t} + b\beta^2 e^{-\beta t}$$

Since, acceleration is (+)ve then velocity is increasing with time.

376. Under the action of a constant force, a particle is experiencing a constant acceleration. The power is

(a) Zero
(b) Positive constant
(c) Negative constant
(d) Increasing uniformly with time
(e) Decreasing uniformly with time

Kerala CEE - 2017

Ans. (d) : We are given that the particle is under a constant force and is experiencing a constant acceleration.

Now, we know that power is a rate of doing work

$$P = \frac{dw}{dt}$$

$$P = \frac{d}{dt}(F.x)$$

$$P = \left(\frac{dx}{dt}\right)F$$

$$P = F.v$$

$$P = F\,at \qquad \left(\begin{array}{c}\therefore a = \dfrac{v}{t} \\ v = at\end{array}\right)$$

$$P \propto t$$

F and a are constant thus, the power increases continuously w.r.to time.

377. A person from a truck, moving with a constant speed of 60 Km/h, throws a ball upwards with a speed of 60 km/h. Neglecting the effect of Earth and choose the correct answer from the given choice.

(a) The person cannot catch the ball when it comes down since the truck is moving
(b) The person cannot catch the ball when it comes down, if the truck is stopped immediately after throwing the ball

@apna_pdf

(c) The person can catch the ball when it comes down, if the truck moves with speed less then 60 km/h but does not stop

(d) The person can catch the ball when it comes down, if the truck moves with speed more than 60 km/h

(e) The person can catch the ball when it comes down, if the truck continues to move with a constant speed of 60 km/h

Kerala CEE - 2017

Ans. (e) : When a person throws a ball (60 km/h) up in moving truck (60 km/h) the ball does come straight back to thrower as though the truck were at rest.

This is an iron-clad evidence for the law of inertia as the horizontal motion of ball before during and after the catch is the same.

The person can catch the ball when it comes down, if the truck continues to move with a constant speed of 60 km/h

378. Two object P and Q, travelling in the same direction starts from rest. While the object P starts at time t = 0 and object Q starts later at t = 30 min. The object P has an acceleration of 40 km/h^2. To catch P at a distance of 20 Km, the acceleration of Q should be

(a) 40 km/h^2
(b) 80 km/h^2
(c) 100 km/h^2
(d) 120 km/h^2
(e) 160 km/h^2

Kerala CEE - 2017

Ans. (e) : At t = 0

$a = 40 \text{ km/h}^2$

$s = 20 \text{ km}$

The time taken by object P to cover 20 km will be

$$s = ut + \frac{1}{2}at^2$$

$$s = \frac{1}{2}at^2 \qquad (\because u = 0)$$

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2\times 20}{40}} = 1$$

$t = 1$ hour

Time taken by Q will be $\frac{1}{2}$ hour, The acceleration of Q,

$$a = \frac{2s}{t^2} = \frac{2\times 20}{\left(\frac{1}{2}\right)^2} = \frac{40\times 4}{1} = 160$$

$a = 160 \text{ km/h}^2$

379. Two balls of equal masses are thrown upward along the same vertical direction at an interval of 2s, with the same initial velocity of 39.2 m/s. The two balls will collide at a height of

(a) 39.2m
(b) 73.5m
(c) 78.4m
(d) 117.6m

VITEEE-2013

Ans. (b) : Let two balls collide at a height of s from the ground after t second when second ball is thrown upward. So, time taken by first ball to reach the point of collision = (t + 2) sec.

For first ball,

$$s = 39.2\,(t+2) + \frac{1}{2}(-9.8)\,(t+2)^2$$

$$s = 39.2\,(t+2) - 4.9\,(t+2)^2 \;\ldots\ldots(1)$$

For second ball,

$$s = 39.2t + \frac{1}{2}(-9.8)\,t^2$$

$$s = 39.2t - 4.9\,t^2 \qquad \ldots\ldots(2)$$

From equation (1) and (2),

$$39.2(t+2) - 4.9(t+2)^2 = (39.2)t - 4.9t^2$$

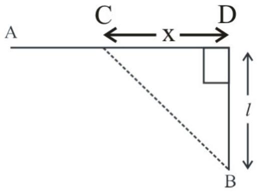
$t = 3$ sec

From equation (2),

$$s = 39.2 \times 3 - 4.9 \times (3)^2$$

$$s = 117.6 - 44.1 = 73.5 \text{ m}$$

380. From a point A and a highway, one has to get by car as soon as possible to point B located in the field at a perpendicular distance l from the highway. The car moves in the field η times slower than on the highway. Take $\eta > 1$ so that if the speed of the car on the highway is ηv, it is v in the field.



At what distance x from point D, one must turn off the highway?

(a) $\frac{l}{\eta}$
(b) $\frac{l}{\sqrt{\eta^2-1}}$
(c) $\frac{l}{\sqrt{\eta^2-2}}$
(d) $\frac{l}{\sqrt{\eta^2-2}}$

SCRA-2015

Ans. (b) : Let the car turn off the highway at point C and let distance CD = x

If v is the velocity of the car in the field, the ηv is the velocity on the highway.

Then, time travelled on highway,

$$t_1 = \frac{AD - x}{\eta v}$$

and time travelled through the field,

$$t_2 = \frac{\sqrt{l^2 + x^2}}{v}$$

For t to be minimum,

$$\frac{d}{dx}(t_1 + t_2) = 0$$

$$\frac{d}{dx}\left[\frac{1}{v}\left\{\frac{AD - x}{\eta} + \sqrt{l^2 + x^2}\right\}\right] =$$

@apna_pdf

$$-\frac{1}{\eta}+\frac{x}{\sqrt{l^2+x^2}}=0$$

$$l^2+x^2=\eta^2x^2$$

$$x=\frac{l}{\sqrt{\eta^2-1}}$$

381. The velocity of a particle moving in the positive direction of x-axis is given by $v=\alpha\sqrt{x}$ where α is a positive constant. The acceleration of the particle will be

(a) α^2 (b) $\frac{\alpha^2}{2}$

(c) $2\alpha^2$ (d) $\alpha^{3/2}$

SCRA-2014

Ans. (b) : Given,

$$v=\frac{dx}{dt}=\alpha\sqrt{x}$$

$$v=\alpha\sqrt{x} \qquad \text{....(i)}$$

We know,

$$\frac{dv}{dt}=\frac{dv}{dx}\cdot\frac{dx}{dt}=a$$

Differentiating the equation (i), we get

$$\frac{dv}{dt}=\frac{dv}{dx}\cdot\frac{dx}{dt}=\frac{dv}{dx}.v=a$$

$$a=\alpha\times\frac{1}{2\sqrt{x}}\times\alpha\sqrt{x} \qquad \left[\because v=\alpha\sqrt{x}\ \&\ \frac{d}{dx}\sqrt{x}=\frac{1}{2\sqrt{x}}\right]$$

$$a=\frac{\alpha^2}{2}$$

382. A particle motion on a space curve is governed by x = 2 sin t, y = 3 cos t and z = $\sqrt{5}$ sin *t*. The speed of the particle at any instant is

(a) $3\sqrt{2}\ \sin t$ (b) $3\sqrt{\cos 2t}$

(c) $3\sqrt{\sin 2t}$ (d) independent of time

SCRA-2014

Ans. (d) : Given,

$$x=2\sin t$$

$$y=3\cos t$$

$$z=\sqrt{5}\sin t$$

Velocity of particle along the x-axis at time t,

$$v_x=\frac{dx}{dt}$$

$$v_x=\frac{d(2\sin t)}{dt}$$

$$v_x=2\cos t$$

Velocity of particle along the y-axis at time t,

$$v_y=\frac{dy}{dt}$$

$$v_y=\frac{d(3\cos t)}{dt}$$

$$v_y=-3\sin t$$

Velocity of particle along the z-axis at time t,

$$v_z=\frac{dz}{dt}$$

$$v_z=\frac{d(\sqrt{5}\sin t)}{dt}$$

$$v_z=\sqrt{5}\cos t$$

$$\vec{v}=v_x\hat{i}+v_y\hat{j}+v_z\hat{k}$$

Hence, overall speed of particle at instant is

$$|v|=\sqrt{4\cos^2 t+9\sin^2 t+5\cos^2 t}$$

$$|v|=\sqrt{9(\cos^2 t+\sin^2 t)}$$

$\therefore$ v = 3 m/s.

383. A car accelerates from rest to a speed of 10 m/s. Let the energy spent be E. If we accelerate the speed of the car from 10 m/s to 20 m/s, the energy spent will be

(a) E (b) 2E

(c) 3E (d) 4E

SCRA-2013

Ans. (c) : Energy required to accelerate from 0 to 10m/s

Change in kinetic energy-

$$\Delta K.E.=\frac{1}{2}m(v^2-u^2)$$

$$\Delta K.E.=\frac{1}{2}m(100-0)$$

$$\Delta K.E.=50\text{ m}$$

$$E=50\text{ m}$$

Now,

Change in K.E. from 10 to 20m/s

$$\Delta K.E.=\frac{1}{2}m(20^2-10^2)$$

$$\Delta K.E.=\frac{1}{2}m\,(400-100)=\frac{300}{2}m$$

$$\Delta K.E.=150\text{ m}$$

$\because$ E = 50 m

So, 150 m = 3E

384. A person covers one-third of the distance with 10 km/h, the second one-third distance with 20 km/h and the rest one-third distance with 60 km/h. What is the average speed ?

(a) 12 km/h (b) 18 km/h

(c) 24 km/h (d) 30 km/h

SCRA-2012

Ans. (b) : Let the total distance travelled be x.

$$\text{Average Speed}=\frac{\text{Total Distance}}{\text{Total Time taken}}$$

$$\text{Total time taken}=t_1+t_2+t_3$$

$$=\frac{x}{3\times10}+\frac{x}{3\times20}+\frac{x}{3\times60}$$

@apna_pdf

$$= \frac{x}{30} + \frac{x}{60} + \frac{x}{180}$$

$$= \frac{6x + 3x + x}{180} = \frac{10x}{180} = \frac{x}{18}$$

$$v_{avg} = \frac{x}{x/18} \text{ km/h}$$

$$v_{avg} = 18 \text{ km/h}$$

385. A particle moves rectilinearly with retardation α whose magnitude is dependent of velocity as $\alpha = b\sqrt{v}$ where 'b' is a positive constant. The initial velocity of the particle is v_0. How long will the particle move before coming to rest?

(a) $\frac{\sqrt{v_0}}{b}$ (b) $\frac{2\sqrt{v_0}}{b}$

(c) $\frac{3\sqrt{v_0}}{b}$ (d) $\frac{v_0}{b}$

SCRA-2011

Ans. (b) : In this problem it is clear that acceleration is not constant and is depends on velocity. It means, we should use calculus as,

$$\frac{dv}{dt} = -\alpha = -b\sqrt{v}$$

$$\frac{dv}{\sqrt{v}} = -b.dt$$

$$\int_{v_0}^{0} \frac{dv}{\sqrt{v}} = -\int_0^t bdt$$

$$\left[2v^{1/2}\right]_{v_0}^{0} = -\left[bt\right]_0^t$$

$$-2v_0^{1/2} = -bt$$

$$t = \frac{2\sqrt{v_0}}{b}$$

386. A body falls freely for 10s. Its average velocity during this journey is (Take, g = 10 ms^{-2}) :

(a) 100 ms^{-1} (b) 10 ms^{-1}

(c) 50 ms^{-1} (d) 5 ms^{-1}

Karnataka CET-2016

Ans. (c) : Given, g = 10 m/s^2, t = 10 s

Initial velocity of body (u) = 0 m/s

Distance covered (s) = $ut + \frac{1}{2}gt^2$

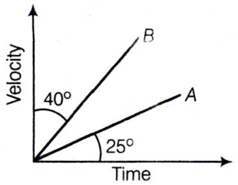
$\therefore$ $s = 0 + \frac{1}{2} \times 10 \times (10)^2 = 500$ m

We know that,

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Time Interval}}$$

$$\text{Average velocity } (v_{avg}) = \frac{s}{t} = \frac{500}{10} = 50 \text{m/s}$$

387. The velocity - time graph for two bodies A and B are shown in figure. Then, the acceleration of A and B are in the ratio :



(a) sin 25° to sin 50° (b) tan 25° to tan 40°

(c) cos 25° to cos 50° (d) tan 25° to tan 50°

Karnataka CET-2015

Ans. (d) : We know that,

$$\text{Acceleration (a)} = \frac{dv}{dt}$$

- Slop of (v–t) graph = tanθ
- The slop of velocity- time graph gives acceleration.

$$\frac{a_A}{a_B} = \frac{\tan\theta_1}{\tan\theta_2} = \frac{\tan 25^\circ}{\tan 50^\circ} \quad \begin{Bmatrix} \because \theta_2 + 40^\circ = 90^\circ \\ \theta_2 = 50^\circ \end{Bmatrix}$$

$a_A : a_B$ = tan 25° :tan 50°

388. A car moves from A to B with a speed of 30 km/h and from B to A with a speed of 20 km/h. What is the average speed of the car ?

(a) 25 km/h (b) 24 km/h

(c) 50 km/h (d) 10 km/h

Karnataka CET-2014

Ans. (b) : Given that,

Speed of car (A to B) = 30 km/h

Speed of car (B to A) = 20 km/h

$$\underset{A}{\vdash} \xrightarrow{v_1} \qquad \xleftarrow{v_2} \underset{B}{\dashv}$$

$$\text{Average speed of car (A to B) and (B to A)} = \frac{2v_1v_2}{v_1 + v_2}$$

$\therefore$ v_1 = speed of car (A to B), v_2= speed of car (B to A)

$$= \frac{2 \times 30 \times 20}{30 + 20} = \frac{1200}{50} = 24 \text{km/h}$$

389. A motorboat covers a given distance in 6 h moving downstream on a river. It covers the same distance in 10 h moving upstream. The time it takes to cover the same distance in still water is :

(a) 9 h (b) 7.5 h

(c) 6.5 h (d) 8 h

Karnataka CET-2010

Ans. (b) : Let v_w be the velocity of water, v_b be the velocity of motorboat in still water.

The distance x covered by the motorboat in moving downstream in 6 hours is

$$x = (v_b + v_w) \times 6 \quad \text{.......(i)}$$

Same distance x covered by the motor boat in moving upstream in 10 hours is

$$x = (v_b - v_w) \times 10 \quad \text{.......(ii)}$$

Equating (i) and (ii) we get

$$(v_b + v_w) \times 6 = (v_b - v_w) \times 10$$

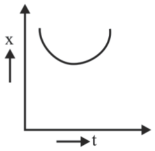
@apna_pdf

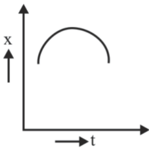
$$3v_b + 3v_w = 5v_b - 5v_w$$
$$8v_w = 2v_b$$
$$v_w = \frac{v_b}{4}$$
$$\therefore\ x = (v_b + v_w) \times 6 = 7.5\ v_b$$

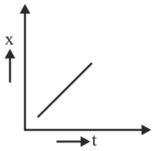
Time taken by the motorboat to cover the same distance in still water is –

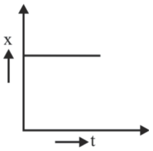
$$t = \frac{x}{v_b} = \frac{7.5v_b}{v_b} = 7.5 \text{ hours.}$$

390. Position - time graph for motion with zero acceleration is

(a)


(b)


(c)


(d)


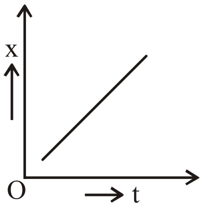
J&K CET- 2011

Ans. (c) : Given that, acceleration, a = 0

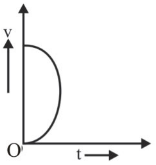
Velocity (v) = constant

$$v = \frac{dx}{dt} = \text{slope}$$

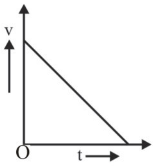
The position-time graph is a straight line.



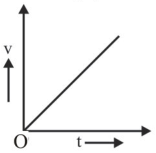
391. Which of the following cannot be speed-time graph?



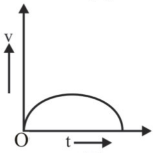
(A)



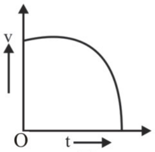
(B)



(C)



(D)



(E)

(a) (B) and (D) (b) (C) and (E)
(c) (D) only (d) (A) only

J&K CET- 2009

Ans. (d) : A particle can have only one speed at one time and it cannot have two speeds at one time. In remaining three graphs v-t slope is possible. Either constant increasing or decreasing or initial increasing acceleration and then decreasing acceleration.

392. The area under the displacement-force curve gives

(a) distance travelled (b) total force
(c) momentum (d) work done

J&K CET- 2008

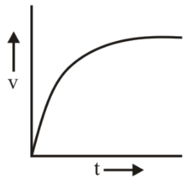
Ans. (d) : The product of force and displacement is the work done.

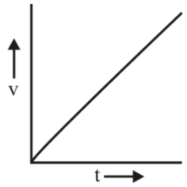
Work done = Force × displacement

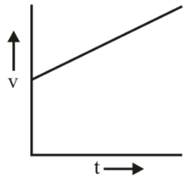
Hence,

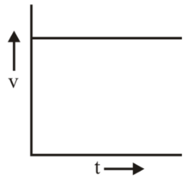
The area under force-displacement curve = work done.

393. A body starts from rest and moves with uniform acceleration. Which of the following graphs represent its motion?

(a)


(b)


(c)


(d)


J&K CET- 2008

Ans. (b) : From the kinematic expression

$$v = u + at$$

Where, v = final velocity, a = acceleration

u = initial velocity, t = time

If the initial velocity is zero then, u = 0

$$v = at \quad \ldots\ldots (i)$$

Compare equation (i) by y = mx + C, we get

$$y = v,\ m = a,\ x = t\ \&\ C = 0$$

This expression is the straight line with slope m = a.

394. A body moving with some initial velocity and having uniform acceleration attains a final velocity v m/s after travelling x m. If its final velocity is $v = \sqrt{180 - 7x}$, find the acceleration of the body

(a) -3.5 m/s^2 (b) -7 m/s^2
(c) -15 m/s^2 (d) -30 m/s^2

J&K CET- 2007

Ans. (a) : Given, $v = \sqrt{180 - 7x}$

Where, x = distance travelled

Let initial velocity = u

and uniform acceleration = a

@apna_pdf

By applying third equation of motion,

$$v^2 = u^2 + 2as$$

$$(\sqrt{180-7x})^2 = u^2 + 2as$$

$$180 - 7x = u^2 + 2ax$$

On comparing both side, we get–

$$u^2 = 180$$

$$2a = -7 \qquad \text{or} \qquad a = -3.5\ \text{m/s}^2$$

395. A particle moves along x-axis as $x = 4(t-2) + a(t-2)^2$ Which of the following is true?

(a) The initial velocity of particle is 4.
(b) The acceleration of particle is 2a.
(c) The particle is at origin at t = 0.
(d) None of these.

J&K CET- 2005

Ans. (b) : Given,

$$x = 4(t-2) + a(t-2)^2$$

at t = 0,

$$x = 4(0-2) + a(0-2)^2$$

$$x = -8 + 4a$$

$$x = (4a - 8)$$

As we know,

$$v = \frac{dx}{dt} = \frac{d}{dt}[4(t-2)+a(t-2)^2]$$

$$v = 4(1-0) + 2a(t-2) \times (1-0)$$

$$v = 4 + 2a(t-2) \qquad \ldots\ldots(i)$$

at t = 0,

$$v = 4 + 2a(0-2)$$

$$v = (4 - 4a)$$

$$\text{Acceleration} = \frac{dv}{dt} = 0+2a \quad \text{by equation (i)}$$

Acceleration = 2a

396. If the velocity of a particle is given by $v = (180 - 16x)^{1/2}$ m/s, then its acceleration will be

(a) zero (b) $8\ \text{m/s}^2$
(c) $-8\ \text{m/s}^2$ (d) $4\ \text{m/s}^2$

J&K CET- 2004

Ans. (c) : Given that,
velocity of a particle,

$$v = (180 - 16x)^{1/2} \qquad \left(\because\ a = \frac{dv}{dt} = \frac{dx}{dt}\frac{dv}{dx} = v\frac{dv}{dx}\right)$$

$$v^2 = (180 - 16x)$$

Differentiate both sides w.r.t x we get

$$2v\frac{dv}{dx} = (0-16)$$

$$v\frac{dv}{dx} = -8 \Rightarrow a = -8\text{m/s}^2$$

397. Position of a particle moving along x–axis is given by $x = 3t - 4t^2 + t^3$, where x is in meter and t in seconds. Find the average velocity of the particle in the time interval from t = 2 sec to 4 sec.

(a) 7 m/s (b) 9 m/s
(c) 13 m/s (d) None of these

J&K CET- 2002

Ans. (a) : Given, $x = 3t - 4t^2 + t^3$

At t = 2s,

Then, $x = 3(2) - 4(2)^2 + (2)^3 = -2$

At t = 3s

$$x = 3(3) - 4(3)^2 + (3)^3 = 0$$

At t = 4s

$$x = 3(4) - 4(4)^2 + (4)^3 = 12$$

So,

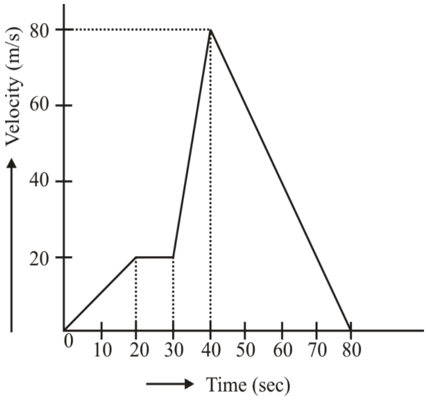
Total displacement of particle from t = 2 to t = 4s is = 12m – (–2m) = 14m

The time interval from t = 2 to t = 4s is = 2s

Then the average velocity of the particle is

$$= \frac{\text{total displacement}}{\text{total time}} = \frac{14}{2} = 7\,\text{m/s}$$

398. The velocity-time graph of moving object is given in the figure. Find the maximum acceleration of the body and distance travelled by the body in the interval of time in which this acceleration exists.



(a) $6\ \text{m/s}^2$, 500m (b) $3\ \text{m/s}^2$, 200m
(c) $-6\ \text{m/s}^2$, 500m (d) $-3\ \text{m/s}^2$, 500m

J&K CET- 2002, 2001

Ans. (a) : Acceleration from 0 to 20 s will be -

$$\therefore\ a_1 = \frac{\text{Change in velocity}}{\text{Time}} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{20-0}{20-0} = 1\text{m/s}^2$$

Acceleration from 20 to 30 s will be -

$$a_2 = 0,$$

Acceleration from 30 to 40 s will be -

$$a_3 = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{80-20}{40-30} = \frac{60}{10} = 6\ \text{m/s}^2$$

Acceleration from 40 to 80 s will be -

$$a_3 = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{80-0}{80-40} = \frac{80}{40} = 2\text{m/s}^2$$

So, comparing the magnitude in each interval we can say that maximum acceleration is 6m/s^2

$\because$ Distance = Velocity × time = area of the trapezium

$$= \frac{1}{2} \times (20+80) \times (40-30)\text{m}$$

$$= \frac{100 \times 10}{2} = 500\text{m}$$

@apna_pdf

399. An equation $x = t^3 - 2t$ denotes relationship between displacement and time. At t = 4 sec, acceleration is given by

(a) 12 units (b) 22 units
(c) 24 units (d) 26 units

J&K CET- 2001

Ans. (c) : Given,

$$x = t^3 - 2t$$

$$\text{Velocity} = \frac{dx}{dt} = 3t^2 - 2 \qquad \left(\because\ v = \frac{dx}{dt}\ \&\ a = \frac{d^2x}{dt^2}\right)$$

$$\text{Acceleration} = \frac{d^2x}{dt^2} = 6t - 0$$

At t = 4, acceleration = 6×4 = 24 units

400. A particle is subjected to acceleration $a = \alpha t + \beta t^2$, where α and β are constants. The position and velocity of the particle at t = 0 are x_0 and v_0 respectively. The expression for position of particle at time *t* is

(a) $x(t) = x_0 + v_0 t + \frac{1}{6}\alpha t^3 + \frac{1}{12}\beta t^4$

(b) $x(t) = x_0 + v_0 t + \frac{1}{6}\alpha t^2 + \frac{1}{24}\beta t^3$

(c) $x(t) = x_0 + v_0 t + \frac{1}{12}\alpha t^2 + \frac{1}{6}\beta t^3$

(d) $x(t) = x_0 + v_0 t + \frac{1}{6}\alpha t^2 + \frac{1}{12}\beta t^3$

J&K CET- 2001

Ans. (a) : Given,

Acceleration $a = \alpha t + \beta t^2$

$$a = \frac{dv}{dt} = \alpha t + \beta t^2$$

or $dv = (\alpha t + \beta t^2)dt$

Integrating it within the condition of motion,

$$\int_{v_0}^{v} dv = \int_0^t \left(\alpha t + \beta t^2\right) dt$$

$$v - v_0 = \frac{1}{2}\alpha t^2 + \frac{\beta t^3}{3}$$

$$v - v_0 = \frac{1}{2}\alpha t^2 + \frac{1}{3}\beta t^3$$

$$\frac{dx}{dt} = v_0 + \frac{1}{2}\alpha t^2 + \frac{1}{3}\beta t^3 \qquad \left(\because\ v = \frac{dx}{dt}\right)$$

Integrating it again, we get

$$\int_{x_0}^{x} dx = \int_0^t \left(v_0 + \frac{1}{2}\alpha t^2 + \frac{1}{3}\beta t^3\right) dt$$

$$x - x_0 = v_0 t + \frac{1}{6}\alpha t^3 + \frac{1}{12}\beta t^4$$

$$x = x_0 + v_0 t + \frac{1}{6}\alpha t^3 + \frac{1}{12}\beta t^4$$

$$x(t) = x_0 + v_0 t + \frac{1}{6}\alpha t^3 + \frac{1}{12}\beta t^4$$

401. The displacement of an object is given by $x = b + ct^2$, where b = 8 m, c = 2.5 m s^{-2} and t is in seconds. Then the average velocity of the object between t = 2 s and t = 4 s is

(a) 10 m s^{-1} (b) 20 m s^{-1}
(c) 15 m s^{-1} (d) 30 m s^{-1}

J&K CET- 1997

Ans. (c) : Given,

$x = b + ct^2$, b = 8m and c = 2.5 m/s^2

$$v_{avg} = \frac{\text{Total displacement}}{\text{Total time}} \qquad \text{....(i)}$$

At t = 2s, $x = 8 + 2.5(2)^2$ = 18m/s
At t = 4s, $x = 8 + 2.5(4)^2$ = 48m/s

From equation (i)

$$v_{avg} = \frac{48 - 18}{4 - 2}$$

v_{avg} = 15 m/s

402. A car moving on a straight road covers 1/3 of the distance with 25 km/h and rest with 75 km/h. The average speed is

(a) 25 km/hr (b) 45 km/hr
(c) 55 km/hr (d) 75 km/hr

J&K-CET-2014

Ans. (b) : Given,

v_1 = 25 km/h
v_2 = 75 km/h

$$\text{Time} = \frac{\text{distance}}{\text{velocity}}$$

At v_1 = 25 km/h, $T_1 = \frac{d/3}{v_1} = \frac{d}{3\times 25} = \frac{d}{75}$

At v_2 = 75 km/h, $T_2 = \frac{2d}{3\times v_2} = \frac{2d}{3\times 75} = \frac{2d}{225}$

$$v_{avg} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{d}{\frac{d}{75} + \frac{2d}{225}}$$

$$= \frac{d}{5d} \times 225$$

v_{avg} = 45 km/hr

403. If a particle moves with an acceleration, then which of the following can remain constant?

(a) Both speed and velocity
(b) Neither speed nor velocity
(c) Only the velocity
(d) Only the speed

J&K-CET-2012

Ans. (d) : Acceleration is the rate of change of velocity with respect to time. If particle moves with an acceleration, the speed can be a constant.

@apna_pdf

404. A car is moving along a circular path of radius 500 m with a speed of 30 ms^{-1}. If at some instant, its speed increases at the rate of $2ms^{-2}$, then at that instant the magnitude of resultant acceleration will be

(a) 4.7 ms^{-2} (b) 3.8 ms^{-2}
(c) 3 ms^{-2} (d) 2.7 ms^{-2}

UPSEE - 2009

Ans. (d) : Given,

$$v = 30 \text{ m/s}$$
$$r = 500\text{m}$$

In circular motion-

Centripetal acceleration $(a_c) = \dfrac{v^2}{r}$

$$a_c = \frac{900}{500}$$
$$a_c = \frac{9}{5} = 1.8 \text{ m/s}^2$$

Tangential acceleration, $(a_t) = 2 \text{ m/s}^2$

Net acceleration $(a_{net}) = \sqrt{a_t^2 + a_c^2}$

$$= \sqrt{4 + \frac{81}{25}} = \sqrt{\frac{181}{25}}$$

$a_{total} = 2.7 \text{ m/s}^2$

405. A car travels 6 km towards north at an angle of 45º to the east and then travels distance of 4 km towards north at an angle 135º to east. How far is the point from the starting point? What angle does the straight line joining its initial and final position makes with the east?

(a) $\sqrt{50}$ km and $\tan^{-1}(5)$
(b) 10 km and $\tan^{-1}\left(\sqrt{5}\right)$
(c) $\sqrt{52}$ km and $\tan^{-1}(5)$
(d) $\sqrt{52}$ km and $\tan^{-1}\left(\sqrt{5}\right)$

AIIMS-2008

Ans. (c) : Distance traveled along x-direction-

$s_x = (6 - 4) \cos 45^\circ = 2 \cos 45^\circ = \sqrt{2}$ km

And, distance traveled along y- direction-

$s_y = (6 + 4) \cos 45^\circ = 10 \times \dfrac{1}{\sqrt{2}} = 5\sqrt{2}$ km

Net distance travelled from starting point,

$$s = \sqrt{s_x^2 + s_y^2}$$
$$= \sqrt{\left(\sqrt{2}\right)^2 + \left(5\sqrt{2}\right)^2}$$
$$= \sqrt{52} \text{ km}$$

Angle which the resultant makes with the east direction

$$a_s = \tan^{-1}\left(\frac{s_y}{s_x}\right) \Rightarrow \tan^{-1}\left(\frac{5\sqrt{2}}{\sqrt{2}}\right) = \tan^{-1}(5)$$

406. If the displacement of a body varies as the square of elapsed time, then its

(a) Velocity is constant
(b) Velocity varies non-uniformly
(c) Acceleration is constant
(d) Acceleration changes continuously
(e) Momentum is constant

Kerala CEE - 2015

Ans. (c) : Acceleration remains constant if the displacement of body varies as the square of elapsed time.

$$x \propto t^2$$
$$v = \frac{dx}{dt} \propto 2t$$
$$a = \frac{d^2x}{dt^2} \propto 2$$

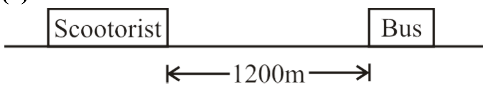
i.e. a = constant

407. A bus is moving with a velocity of $10ms^{-1}$ on a straight road. A scootorist wishes to overtake the bus in one minute of the bus is at a distance of 1.2 km ahead, then the velocity with which he has to chase the bus is

(a) 20 ms^{-1} (b) 25 ms^{-1}
(c) 60 ms^{-1} (d) 40 ms^{-1}
(e) 30 ms^{-1}

Kerala CEE - 2015

Ans. (e) :



Given,

Velocity of Bus (v_B) = 10 m/sec

Distance between Bus and scootorist be = 1200m

Time (t) = 1min = 60 sec.

Let velocity of scootorist = v_s

$$\text{Time} = \frac{\text{Total distance}}{\text{Relative velocity}}$$
$$60 = \frac{1200}{(v_s - 10)}$$

$60 (v_s - 10) = 1200$
$60 v_s - 600 = 1200$
$60 v_s = 1800$
$v_s = 30$ m/sec.

408. The coordinates of a particle moving in x-y plane at any instant of time t are $x = 4t^2$; $y = 3t^2$. The speed of the particle at that instant is

(a) 10t (b) 5t
(c) 3t (d) 2t
(e) $\sqrt{13}$t

Kerala CEE- 2014

Ans. (a) : Given co-ordinate of particle in x–y plane,

$$x = 4t^2$$
$$y = 3t^2$$

Velocity in x direction $(v_x) = \dfrac{dx}{dt} = 8t$

@apna_pdf

Velocity in y direction $(v_y) = \dfrac{dy}{dt} = 6t$

The speed of particle will be given by -

$$v = \sqrt{(v_x)^2 + (v_y)^2}$$

$$v = \sqrt{(8t)^2 + (6t)^2} = \sqrt{64t^2 + 36t^2}$$

$$v = 10t$$

409. A particle starting with certain initial velocity and uniform acceleration covers a distance of 12 m in first 3s and a distance of 30 m in next 3 s. The initial velocity of the particle is

(a) 3 ms^{-1} (b) 2.5 ms^{-1}
(c) 2 ms^{-1} (d) 1.5 ms^{-1}
(e) 1 ms^{-1}

Kerala CEE- 2014

Ans. (e) : Let u be the initial velocity of the particle

Given,

$s_1 = 12m$; $t_1 = 3s$

$s_2 = 30+12 = 42m$; $t_2 = 3+3 = 6s$

From second equation of motion,

$$s_1 = ut_1 + \frac{1}{2}at_1^2$$

$$12 = 3u + \frac{1}{2}a(3)^2$$

$$12 = 3u + \frac{1}{2}a \times 9$$

$$4 = u + \frac{3}{2}a \quad ....(i)$$

$$8 = 2u + 3a$$

$$s_2 = ut_2 + \frac{1}{2}at_2^2$$

$$42 = 6u + \frac{1}{2}a(6)^2$$

$$42 = 6u + \frac{1}{2}a \times 36$$

$$14 = 2u + 6a \quad ....(ii)$$

eq^n (ii) – 2×eqn (i)

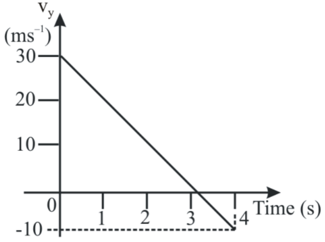
$a = 2m/sec^2$

Putting the value of a in equation (i)

$$4 = u + \frac{3}{2} \times 2$$

u = 1 m/sec.

410. The velocity-time graph for the vertical component of the velocity of a body thrown upwards from the ground and landing on the roof of a building is given in the figure. The height of the building is



(a) 50 m (b) 40 m
(c) 20 m (d) 30 m
(e) 10 m

Kerala CEE- 2013

Ans. (b) : We know, (v–t) graph area give the distance/displacement then, for Height (h)

h = Area under v – t graph

$$= \frac{1}{2} \times \text{base} \times \text{height} - \frac{1}{2}\text{base} \times \text{height}$$

$$= \frac{1}{2} \times 3 \times 30 - \frac{1}{2} \times 1 \times 10$$

= 45 m – 5 m = 40 m.

411. The distance x covered by a particle varies with time t as $x^2 = 2t^2 + 6t + 1$. Its acceleration varies with x as

(a) x (b) x^2
(c) x^{-1} (d) x^{-3}
(e) x^{-2}

Kerala CEE- 2013

Ans. (d) : Given,

$$x^2 = 2t^2 + 6t + 1 \quad ....(i)$$

Differentiating the above equation (i) w.r.to t we get

$$2x\frac{dx}{dt} = 4t + 6 + 0$$

$$2xv = 4t + 6$$

$$xv = 2t + 3 \quad ....(ii)$$

Equation (ii) is differentiated w.r.to t we get

$$x\frac{dv}{dt} + v\frac{dx}{dt} = 2 + 0$$

$$xa + v^2 = 2$$

$$a = \frac{2 - v^2}{x} \quad ....(iii)$$

From equation (ii)

$$v = \frac{2t+3}{x}$$

Put this value in (iii)

$$a = \left[2 - \left(\frac{2t+3}{x}\right)^2\right]\frac{1}{x}$$

$$a = \left[2 - \frac{(2t+3)^2}{x^2}\right]\frac{1}{x}$$

$$a = \frac{1}{x}\left[\frac{2x^2 - (2t+3)^2}{x^2}\right]$$

$$= \frac{1}{x^3}\left[4t^2 + 12 + 2 - 4t^2 - 9 - 12t\right]$$

$$a = \frac{-7}{x^3}$$

$$a \propto x^{-3}$$

412. A billiard ball of mass m and radius r, when hit In a horizontal direction by a cue at a height h above its centre, acquired a linear velocity v_0. The angular velocity ω_0 acquired by the ball is

@apna_pdf

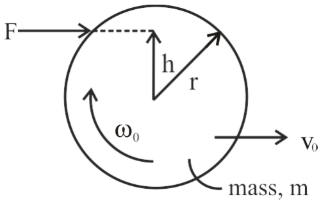
(a) $\frac{5v_0r^2}{2h}$ (b) $\frac{2v_0r^2}{5h}$

(c) $\frac{2v_0h}{5r^2}$ (d) $\frac{5v_0h}{2r^2}$

(e) $\frac{5v_0h^2}{2r^2}$

Kerala CEE 2012

Ans. (d) :



Torque acted upon the ball (τ) = Iα...........(i)

Torque acting on the ball must also be equal to the product of the external acting force F and the perpendicular distance between the line of action of force from the axis of rotation.

τ = F × h ....(ii)

Equating equation (i) & (ii)

$$I\alpha = F \times h$$

$$Fh \sin 90 = I\alpha$$

$$Fh = I\alpha$$

Where $\alpha = \frac{\omega_0}{t}$ and $I = \frac{2}{5}mr^2$

$$Fh = \frac{2}{5}mr^2\frac{\omega_0}{t}$$

$$mah = \frac{2}{5}mr^2 \ \frac{\omega_o}{t}$$

$$\frac{v_o}{t}h = \frac{2}{5}r^2\frac{\omega_o}{t}$$

$$v_oh = \frac{2}{5}r^2\omega_o$$

$$\omega_o = \frac{5}{2}\frac{v_oh}{r^2}$$

$$\boxed{\omega_o = \frac{5}{2}\frac{v_oh}{r^2}}$$

413. A particle moving along a straight line covers half of the distance with a speed of 3 ms^{-1}. The other half of the distance is covered in two equal time intervals with speed of 4.5 ms^{-1} and 7.5 ms^{-1}. The average speed of the particle (in ms^{-1}) is

(a) 5.0 (b) 5.5

(c) 5.8 (d) 4.0

(e) 4.8

Kerala CEE 2012

Ans. (d) : Let the Total distance be = d

Distance covered with 3m/sec is d/2

and $\frac{d}{4}$ and $\frac{d}{4}$ distance covered with 4.5 m/s and 7.5 m/sec.

Then,

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{d}{\frac{d}{2\times3}+\frac{d}{4\times4.5}+\frac{d}{4\times7.5}}$$

$$= \frac{d}{\frac{d}{6}+\frac{d}{18.0}+\frac{d}{30.0}} = \frac{d\times90}{15d+5d+3d} = \frac{90}{23}$$

$$= 3.91 \approx 4\text{m/sec}$$

414. A particle crossing the origin of co-ordinates at time t = 0, moves in the xy-plane with a constant acceleration a in the y-direction. If its equation of motion is y = bx^2 (b is a constant), its velocity component in the x-direction is

(a) $\sqrt{\frac{2b}{a}}$ (b) $\sqrt{\frac{a}{2b}}$

(c) $\sqrt{\frac{a}{b}}$ (d) $\sqrt{\frac{b}{a}}$

(e) $\sqrt{ba}$

Kerala CEE - 2011

Ans. (b) :

$\because \quad y = bx^2$

Differentiating the above equation w.r.to time(t)-

$$\frac{dy}{dt} = 2bx\frac{dx}{dt} = 2bxv_x$$

Where, v_x = Velocity in x–direction

Again differentiating the above equation w.r.to time (t)-

$$\frac{d^2y}{dt^2} = 2b\ v_x\frac{dx}{dt} + 2xb\frac{dv_x}{dt}$$

$$\frac{d^2y}{dt^2} = 2b\ v_x^2 + 2xb\ \frac{dv_x}{dt}$$

$\because \frac{dv_x}{dt} = 0$ [There is no acceleration in x- direction]

$$\frac{d^2y}{dt^2} = a = 2b\ v_x^2$$

$$a = 2b\ v_x^2 \Rightarrow v_x = \sqrt{\frac{a}{2b}}$$

415. A particle is moving with constant acceleration from A to B in a straight line AB. If u and v are the velocities at A and B respectively then its velocity at the midpoint C will be

(a) $\left(\frac{u^2+v^2}{2u}\right)^2$ (b) $\frac{u+v}{2}$

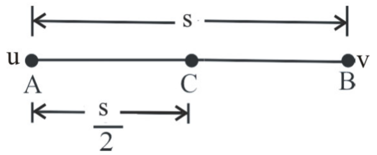
(c) $\frac{v-u}{2}$ (d) $\sqrt{\frac{u^2+v^2}{2}}$

(e) $\sqrt{\frac{v^2-u^2}{2}}$

Kerala CEE - 2011

@apna_pdf

Ans. (d) :



Let distance AB = s, and constant acceleration = a

The velocity of the particle changes from u to v when it moves through the distances (s).

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$s = \frac{v^2-u^2}{2a} \Rightarrow a = \frac{v^2-u^2}{2s} \text{ ....(i)}$$

Let velocity at C = v_1

Distance AC = $\frac{s}{2}$

Velocity at midpoint is-

$$v_1^2 = u^2 + 2a\times\frac{s}{2} \text{ ....(ii)}$$

From equation (i) and (ii), we get

$$v_1^2 = u^2 + 2\left(\frac{v^2-u^2}{2s}\right)\frac{s}{2}$$

$$v_1^2 = u^2 + \frac{v^2-u^2}{2}$$

$$v_1^2 = \frac{2u^2+v^2-u^2}{2}$$

$$v_1^2 = \frac{u^2+v^2}{2}$$

$$\boxed{v_1 = \sqrt{\frac{u^2+v^2}{2}}}$$

416. An aircraft is flying at a height of 3400 m above the ground. If the angle subtended at a ground observation point by the aircraft positions 10 s apart is 30º, then the speed of the aircraft is

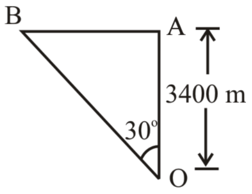
(a) 19.63 ms^{-1} (b) 1963 ms^{-1}

(c) 108 ms^{-1} (d) 196.3 ms^{-1}

(e) 10.8 ms^{-1}

Kerala CEE - 2011

Ans. (d) : Let the observation point at the ground be 'O' A and B are the positions of aircraft for which $\angle BOA = 30^o$ and time taken by aircraft from A to B is 10s.



$$\text{In } \Delta \text{ BOA}, \tan\theta = \frac{AB}{OA} \Rightarrow AB = OA\tan30^o$$

$$AB = \frac{3400}{\sqrt{3}}$$

$$\text{Speed of aircraft} = \frac{\text{Distance travelled by aircraft}}{\text{Time}} = \frac{AB}{10}$$

$$v = \frac{3400}{10\times\sqrt{3}} = \frac{340}{\sqrt{3}}$$

$$v = 196.3 \text{m/s}$$

417. A bus begins to move with an acceleration of 1 ms^{-2}. A man who is 48 m behind the bus starts running at 10 ms^{-1} to catch the bus. The man will be able to catch the bus after

(a) 6 s (b) 5 s

(c) 3 s (d) 7 s

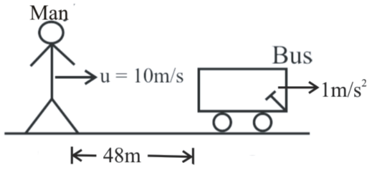
(e) 8 s

Kerala CEE - 2011

Ans. (e) : Given that, initial velocity of man with respect to bus, u = 10m/s

Acceleration of man with respect to bus a = +1 m/s^2

Distance between Man and Bus s = 48 m



According to the question-

Let time to catch the bus by man is the distance travelled by = Distance travelled by bus + distance between man and bus

$$10t = \frac{1}{2}at^2 + 48$$

$$10t = \frac{t^2}{2} + 48$$

$$t^2 - 20t + 96 = 0$$

$$t^2 - 12t - 8t + 96 = 0$$

$$(t-8)(t-12) = 0$$

$$t = 8s \text{ and } t = 12s$$

Hence, man will be able to catch the bus after 8 sec.

418. The position of a particle is given by $\vec{r} = 2t^2\hat{i} + 3t\hat{j} + 4\hat{k}$, where t is in second and the coefficients have proper units for $\vec{r}$ to be in meter. The $\vec{a}$ (t) of the particle at t = 1 s is

(a) 4 ms^{-2} along y- direction

(b) 3 ms^{-2} along x- direction

(c) 4 ms^{-2} along x- direction

(d) 2 ms^{-2} along z- direction

(e) 3 ms^{-2} along z- direction

Kerala CEE - 2010

Ans. (c) : Given that, the position vector of a particle is

$$\vec{r} = 2t^2\hat{i} + 3t\hat{j} + 4\hat{k}$$

$$\because \quad \text{Velocity}, \vec{v} = \frac{d\vec{r}}{dt} = 4t\hat{i} + 3\hat{j}$$

$$\text{Acceleration}, a = \frac{d\vec{v}}{dt} = 4\hat{i}$$

a = $4m/s^2$, in x–direction.

@apna_pdf

419. A passenger getting down from a moving bus falls in the direction of the motion of the bus. This is an example for
(a) Moment of inertia
(b) Second law of motion
(c) Third law of motion
(d) Inertia of rest
(e) Inertia of motion

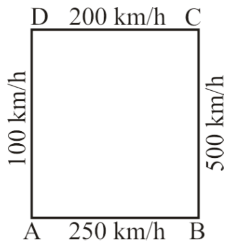
Kerala CEE - 2010

Ans. (e) : When the bus stop suddenly, the feet of passenger stop with the bus but the upper part of passenger tries to remains in motion due to inertia of motion and tends to fall in the forward direction.

420. An aeroplane flies around a square field ABCD of each side 1000 km. Its speed along AB is 250 kmh^{-1}, along BC 500 kmh^{-1}, along CD 200 kmh^{-1}, and along DA 100 kmh^{-1}. Its average speed (in kmh^{-1}) over the entire trip is
(a) 225.5 (b) 175.5
(c) 125.5 (d) 310.5
(e) 190.5

Kerala CEE - 2010

Ans. (e) :



Side of square = 1000 km
Time taken by aeroplane along each side of square.

$$\text{Time along the AB} = \frac{\text{Distance}}{\text{Speed}} = \frac{1000}{250} = 4\text{h}$$

$$\text{Time along the BC} = \frac{1000}{500} = 2\text{h}$$

$$\text{Time along the CD} = \frac{1000}{200} = 5\text{h}$$

$$\text{Time along the AD} = \frac{1000}{100} = 10\text{h}$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{4\times1000}{4+2+5+10} = \frac{4000}{21}$$

= 190.5 km/h

421. Free fall of an object (in vacuum) is a case of motion with
(a) Uniform velocity
(b) Uniform acceleration
(c) Variable acceleration
(d) Constant momentum
(e) Uniform speed

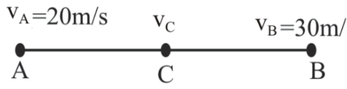
Kerala CEE - 2010

Ans. (b) All freely falling objects fall with same acceleration because the ratio of weight to mass is the same for all object. Such motion is referred to free fall.

422. A body travelling with uniform acceleration crosses two points A and B with velocities 20 ms^{-1} and 30 ms^{-1} respectively. The speed of the body at the mid-point of A and B is nearest to
(a) 25.5 ms^{-1} (b) 25 ms^{-1}
(c) 24 ms^{-1} (d) $10\sqrt{6}$ ms^{-1}
(e) 22 ms^{-1}

Kerala CEE - 2010

Ans. (a) :



We know that, if C is the mid point between A and B, velocity of the particle at point C.

$$\because \quad v_C = \sqrt{\frac{v_A^2+v_B^2}{2}}$$

$$v_C = \sqrt{\frac{(20)^2+(30)^2}{2}}$$

$$v_C = \sqrt{\frac{400+900}{2}}$$

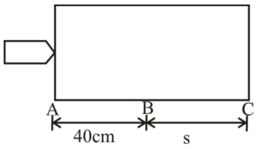
$$v_C = \sqrt{650}$$

$$\boxed{v_C = 25.5\text{m/s}}$$

423. A bullet fired into a fixed wooden block loses half of its velocity after penetrating 40 cm. It comes to rest after penetrating a further distance of
(a) $\frac{22}{3}$cm (b) $\frac{40}{3}$cm
(c) $\frac{20}{3}$cm (d) $\frac{20}{5}$cm
(e) $\frac{26}{5}$cm

Kerala CEE - 2009

Ans. (b) :



The bullet loss half of its velocity after penetrating 40 cm. Using the equation of motion from A to B-
Let initial velocity of bullet = u cm/s

$$\text{Velocity at B} = v = \frac{u}{2}\text{cm/s}$$

$$v^2 - u^2 = 2as$$

$$\frac{u^2}{4} - u^2 = 2a\times40$$

$$a = -\frac{3u^2}{8\times40}\text{cm/s}^2$$

@apna_pdf

Again using the equation of motion from B to C

Velocity at C = 0

$v^2 - u^2 = 2as$

$$0-\frac{u^2}{4} = -2\times\frac{3u^2}{8\times 40}\times s$$

$$\boxed{s=\frac{40}{3}\text{cm}}$$

Hence, s= 40/3 is the distance after which bullet come to rest.

424. A particle is moving under the influence of a force given by F = kx, where k is a constant and x is the distance moved. The energy (in joules) gained by the particle in moving from x = 0 to x = 3 is

(a) 2 k
(b) 3.5 k
(c) 4.5 k
(d) 9 k
(e) 9.5 k

Kerala CEE - 2008

Ans. (c) When the particle moved a distance x under the action of force (F = kx).

Energy gained by particle = Work done due to force to move the particle

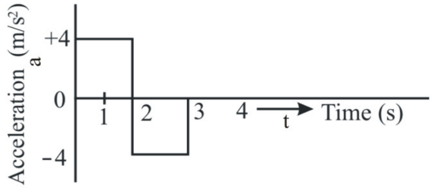
$$E = W = \int_0^3 F dx = \int_0^3 k.x dx$$

$$W = \frac{1}{2}k\left[x^2\right]_0^3$$

$$= \frac{1}{2}k(3^2 - 0^2)$$

$$= \frac{9}{2}k = 4.5k$$

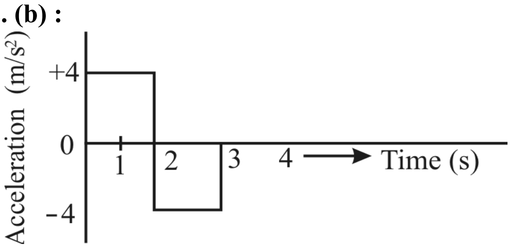
425. A particle starts from rest at t = 0 and moves in a straight line with an acceleration as shown in figure. The velocity of the particle at t = 3 s is



(a) 2 ms^{-1}
(b) 4 ms^{-1}
(c) 6 ms^{-1}
(d) 8 ms^{-1}
(e) 1 ms^{-1}

Kerala CEE - 2008

Ans. (b) :



A particle starts from rest at t = 0 from (a – t) graph

$$\because\ a = \frac{dv}{dt}$$

Change in velocity Δv = Area of (a – t) curved

$$\therefore\ (\Delta v) = \int \vec{a}.dt$$

t = 0, v = 0

t = 3, v = ?

$$\int_0^v dv = \int_0^3 a.dt$$

$$\int_0^v dv = \int_0^2 a.dt + \int_2^3 a.dt$$

In time interval (0-2) acceleration a = 4 m/s^2 and in interval (2-3) acceleration a = – 4 m/s^2

$$\int_0^v dv = \int_0^2 4.dt + \int_2^3 (-4)\ dt$$

$$[v]_0^v = 4[t]_0^2 + (-4)[t]_2^3$$

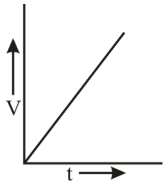
$$[v-0] = 4[2-0] + (-4)[3-2]$$

$$v = 8-4$$

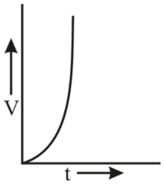
$$\boxed{v = 4\text{m/sec}}$$

426. An object is dropped from rest. Its v-t graph is

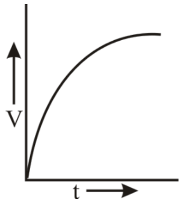
(a)



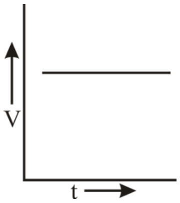
(b)



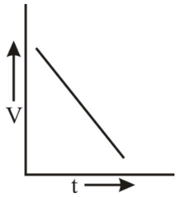
(c)



(d)



(e)



Kerala CEE - 2008

Ans. (a) : When an object is dropped from rest then acceleration of object is equal to acceleration due to gravity (g m/s^2) which is constant and the initial velocity of the object is zero then velocity of the object while increase linearly as predicated by the equation:

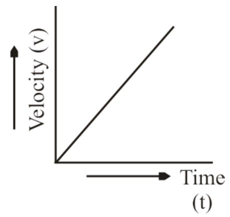
v = u + gt

As object starts from rest, So, u = 0

Then, v = 0 + g.t

v = gt

$v \propto t$



@apna_pdf

427. A particle is released from a height S. At certain height its kinetic energy is three times its potential energy. The height and speed of the particle as that instant are respectively

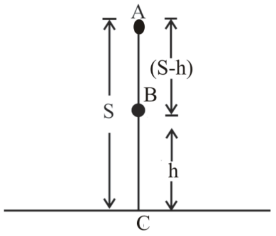
(a) $\frac{S}{4},\frac{3gS}{2}$ (b) $\frac{S}{4},\frac{\sqrt{3gS}}{4}$

(c) $\frac{S}{2},\frac{3gS}{2}$ (d) $\frac{S}{4},\sqrt{\frac{3gS}{2}}$

(e) $\frac{S}{3},\sqrt{\frac{3gS}{2}}$

Kerala CEE 2007

Ans. (d) :



Let, the velocity of particle at point B be 'V_B'.
From conservation of mechanical energy-

$$mgS = mgh + \frac{1}{2}mv_B^2 \quad \text{..........} (i)$$

According to question at point B -

$$(K.E.) = 3\times(P.E.)$$

$$\frac{1}{2}mv_B^2 = 3mgh$$

$$v_B^2 = 6gh \text{ ....}(ii)$$

From equation (i) and (ii)

$$mgS = mgh + \frac{1}{2}m\times 6gh$$

$$S = h + 3h$$
$$S = 4h$$
$$h = S/4$$

From equation (ii)

$$v_B = \sqrt{6g\times\frac{S}{4}} = \sqrt{\frac{3}{2}gS}$$

428. Two cars A and B are travelling in the same direction with velocities v_1 and v_2 ($v_1 > v_2$). When the car A is at a distance d behind the car B, the driver of the car A applies the brake producing uniform retardation, a. There will be no collision when :

(a) $d < \left(\frac{v_1-v_2}{2a}\right)$ (b) $d > \frac{v_1^2-v_2^2}{2a}$

(c) $d > \frac{(v_1-v_2)^2}{2a}$ (d) $d < \frac{v_1^2-v_2^2}{2a}$

(e) none of these

Kerala CEE 2006

Ans. (c) : Given that, two cars A and B are travelling in the same direction with velocities v_1 and v_2 ($v_1 > v_2$) when the car A is at a distance d behind the car B.

∴ Initial velocity of car A with respect to car B = $v_1 - v_2$
Final velocity of car A with respect to car B = 0
Retardation = – a m/s^2
From equation of motion

$$v^2 = u^2 + 2\,a.s$$

$$(0)^2 = (v_1 - v_2)^2 - 2a.d \qquad [\because s = d]$$

$$0 = (v_1 - v_2)^2 - 2ad$$

$$2ad = (v_1 - v_2)^2$$

$$d = \frac{(v_1 - v_2)^2}{2a}$$

If the distance between two cars is 'd' then collision will take place at distance

$$d = \frac{(v_1 - v_2)^2}{2a}$$

To avoid collision,

$$d > \frac{(v_1 - v_2)^2}{2a}$$

429. Two trains, each of length 200 m are running on parallel tracks. One overtakes the other in 20 s and one crosses the other in 10 s. The velocities of the two trains are :

(a) 5 m/s, 10 m/s (b) 10 m/s, 30 m/s

(c) 15 m/s, 5 m/s (d) 20 m/s, 21 m/s

(e) 10 m/s, 5 m/s

Kerala CEE 2006

Ans. (b) : Given that, two trains, each of length 200m are running on parallel tracks.
Let, Velocity of first train = v_1
Velocity of second train = v_2
When one over takes that means moving in same direction
Relative speed = $(v_2 - v_1)$
Time (t) = 20s
Distance (d) = 200 + 200 = 400 m

$$(v_2 - v_1) = \frac{400}{20}$$

$$v_2 - v_1 = 20 \text{..................} (i)$$

When one cross that means moving in opposite direction
t_2 = 10s
Relative velocity = $(v_2 + v_1)$
Distance = (200 + 200)
Distance = 400 m,

$$(v_2 + v_1) = \frac{400}{10}$$

$$v_2 + v_1 = 40 \text{ ....} (ii)$$

Adding equation (i) and equation (ii)

$$(v_2 - v_1) + (v_2 + v_1) = 20 + 40$$

$$\Rightarrow v_2 - v_1 + v_2 + v_1 = 60$$

$$\Rightarrow v_2 = \frac{60}{2}$$

$$\Rightarrow \boxed{v_2 = 30\ m/s}$$

Put the value v_2 in equation (ii)

$$30 + v_1 = 40$$

$$v_1 = 40 - 30$$

$$\boxed{v_1 = 10\,m/s}$$

@apna_pdf

430. A boat travels 50 km east, then 120 km North and finally it comes back to the starting point through the shortest distance. The total time of journey is 3 h. What is the average velocity, in km h^{-1}, over the entire trip?

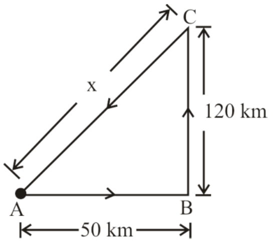
(a) zero (b) 100

(c) 17 (d) 33.33

(e) 86.7

Kerala CEE 2006

Ans. (b) : A boat travels 50 km east, then 120 km North and finally it comes back to starting point through the shortest distance



Let, AC = x

From pythagorean theorem:

$(AC)^2 = (AB)^2 + (BC)^2$

$x^2 = = (50)^2 + (120)^2$

$x^2 = 2500 + 14400$

$x^2 = 16900$

$x = \sqrt{16900}$

$x = 130$ km

AC = 130 km

Total distance (d) = 50 + 120 + 130

d = 300 km

Total time (t) = 3hour

$$\therefore \text{Average velocity } (v) = \frac{\text{Total distance}}{\text{Total time}}$$

$$v = \frac{300}{3}$$

v = 100 km/h

431. The area under acceleration-time graph gives:

(a) Distance travelled

(b) Change in acceleration

(c) Force acting

(d) Change in velocity

(e) Work done

Kerala CEE 2005

Ans. (d) : The area under the acceleration graph for a certain time interval is equal to change in velocity during that time interval.

$$a = \frac{dv}{dt}$$

$$dv = a \times dt$$

$$\int_{v_1}^{v_2} dv = \int_{t_1}^{t_2} a dt$$

432. A body starting from rest moves with constant acceleration. The ratio of distance covered by the body during the 5th second to that covered in 5 s is:

(a) $\frac{9}{25}$ (b) $\frac{3}{5}$

(c) $\frac{25}{5}$ (d) $\frac{1}{25}$

(e) 25

Kerala CEE 2005

Ans. (a) : Given

A body starting from rest moves with constant acceleration.

Initial Velocity (u) = 0

Acceleration = a

We know that

Distance covered in 5th second

$$s_{t\,th} = u + \frac{a}{2}(2t-1)$$

Then, $$s_{5^{th}} = 0 + \frac{a}{2}(2\times5-1)$$

$$s_{5^{th}} = \frac{9a}{2} \text{ ....(i)}$$

And Distance covered in 5 second

$$s_5 = ut + \frac{1}{2}at^2$$

$$s = (0\times5) + \frac{1}{2}\ a(5)^2$$

$$s_5 = 0 + \frac{25}{2}a$$

$$s_5 = \frac{25\ a}{2} \text{ ....(ii)}$$

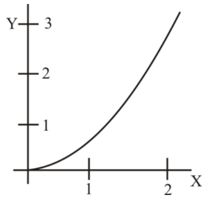
Dividing equation (i) by equation (ii)

$$\therefore \frac{s_{5^{th}}}{s_5} = \frac{\frac{9a}{2}}{\frac{25a}{2}}$$

$$\frac{s_{5^{th}}}{s_5} = \frac{9a\times2}{25a\times2}$$

$$\frac{s_{5^{th}}}{s_5} = \frac{9}{25}$$

433. If the figure below represents a parabola, identify the physical quantities representing Y and X for constant acceleration:



(a) X = time, Y = velocity

(b) X = velocity, Y = time

(c) X= time, Y = displacement

(d) X = time, Y = acceleration

(e) X = velocity, Y = displacement

Kerala CEE 2004

@apna_pdf

Ans. (c) : In the given figure velocity of particle is increasing with time due to constant acceleration. Hence this is displacement-time graph with x-axis as time and y-axis as displacement.

434. Two persons A and B starts from the same location and walked around a square in opposite direction with constant speeds. The square has side 60 m. Speeds of A and B are 4 m/s and 2 m/s respectively. When will they meet first time?

(a) 30 sec (b) 40 sec
(c) 10 sec (d) 20 sec

UPSEE - 2016

Ans. (b) : Given that, A and B are two persons in which speed of A is, $v_A = 4 m/s$, speed of B is, $v_B = 2$ m/s

So, total distance travelled by A and B in time t = perimeter of square

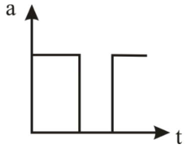
$4t + 2t = 4 \times 60$

$6t = 240$

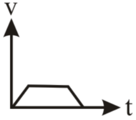
$\boxed{t = 40 sec}$

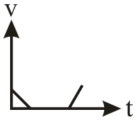
So, person A and B will meet after 40 sec for first time.

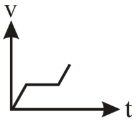
435. Acceleration –time graph of a body is shown below.

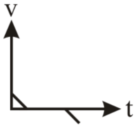


The corresponding velocity-time graph of the same body is-

(a)


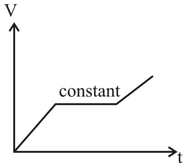
(b)


(c)


(d)


UPSEE - 2014

Ans. (c) :



If the graph is divided into three parts-for the first part acceleration is constant. So velocity increases uniformly.

$$\text{Acceleration (a)} = \frac{dv}{dt}$$

For 2nd part, when a = 0

$$\frac{dv}{dt} = 0$$

v = constant

And the last part acceleration again positive and constant. Hence velocity increases.

So, option c will be correct.

436. A point moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3. Which of the following relation is correct?

(a) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$
(b) $(v_1 - v_2):(v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$
(c) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$
(d) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

UPSEE - 2013

Ans. (b) : Given that, the three successive interval of time t_1, t_2 and t_3 with average velocity v_1, v_2 and v_3.

Suppose 'u' be the initial velocity

Velocity after time t_1, $v_1 = u + at_1$

Velocity after time $t_1 + t_2$, $v_2 = u + a(t_1 + t_2)$

Velocity after time $t_1 + t_2 + t_3$, $v_3 = u + a(t_1 + t_2 + t_3)$

Now $v_1 = \frac{u + v_1}{2} = \frac{u + (u + at_1)}{2} = u + \frac{1}{2}at_1$

Similarly, $v_2 = u + at_1 + \frac{1}{2}at_2$

and $v_3 = u + at_1 + at_2 + \frac{1}{2}at_3$

So, $(v_1 - v_2) = -\frac{1}{2}a(t_1 + t_2)$

and $(v_2 - v_3) = -\frac{1}{2}a(t_2 + t_3)$

$\therefore$ $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$

437. A particle moves along a straight line such that its position x at any time t is $x = 6t^2 - t^3$. Where x is in metre and t is in second, then

(a) at t = 0 acceleration is 12 ms^{-2}
(b) x-t curve has maximum at 4 s
(c) Both (a) and (b) are wrong
(d) Both (a) and (b) are correct

UPSEE - 2009

Ans. (d) : Given equation of distance

$x = 6t^2 - t^3$

Differentiating above equation w.r.t 't' , we get

$$\frac{dx}{dt} = 12t - 3t^2 \text{ ....(i)}$$

$0 = 12t - 3t^2$

$12t = 3t^2$

t = 4 sec

Now, again differentiating equation (i) , we get

$$\frac{d^2x}{dt^2} = 12 - 6t$$

At t = 4 sec

$$\frac{d^2x}{dt^2} = 12 - 6 \times 4 = -12 \text{ i.e. Negative value}$$

Which is indicate the maximum value of x–t curve at t = 4 sec

Now, $\frac{d^2x}{dt^2}$ at t = 0

$$\frac{d^2x}{dt^2} = 12 - 6 \times 0 = 12 \text{ m/s}^2$$

@apna_pdf

438. The numerical ratio of average velocity to average speed is

(a) always less than one
(b) always equal to one
(c) always more than one
(d) equal to or less than one

UPSEE - 2008

Ans. (d) :

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

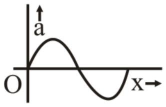
$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

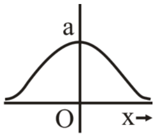
So, ratio is $\dfrac{\text{Average velocity}}{\text{Average speed}} = \dfrac{\text{Total displacement}}{\text{Total distance}}$

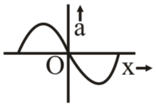
But displacement can be equal to distance but it can never be greater than distance.

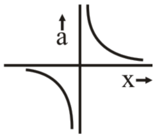
Hence, $\dfrac{\text{Average velocity}}{\text{Average speed}} \le 1$

439. Two identical positive charges are fixed on the y - axis at equal distances from the origin O. A negatively charged particle starts on the x-axis, at a large distance from O, moves along the x-axis, passes through O and moves far away from O. Its acceleration a is taken as positive along its direction of motion. The best graph between the particle's acceleration and its x-coordinate is represented by

(a) 

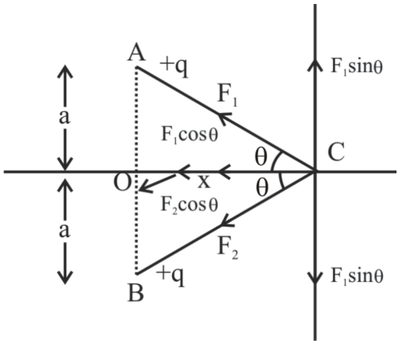
(b) 

(c) 

(d) 

AFMC - 2012
UPSEE - 2008

Ans. (c) :



From figure,

$$F_1 = F_2 = \frac{k\cdot q\cdot q}{\left(a^2 + x^2\right)} \qquad ....(i)$$

The resultant force on the charge q is

$F = F_1\cos\theta + F_2\cos\theta$

$F = 2F_1\cos\theta \; [\because \; F_1 = F_2]$

and $AC = BC = \sqrt{a^2 + x^2}$ and $\cos\theta = \dfrac{x}{\sqrt{a^2 + x^2}}$

So, $F = 2F\cos\theta$

$$F = 2\cdot\frac{k\cdot qq}{(a^2+x^2)}\cdot\frac{x}{\sqrt{a^2+x^2}} \qquad ....(ii)$$

Now, By Newton's third law

$F = ma$ Where m = mass of the charge q'

and a = acceleration

$$\therefore \quad ma = \frac{2\cdot kqqx}{(a^2+x^2)^{3/2}}$$

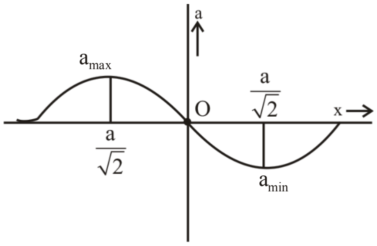
$$a = \frac{2kqq}{m}\frac{x}{(a^2+x^2)^{3/2}} \qquad ....(iii)$$

At initial stage acceleration is zero but after then the acceleration is given by equation (iii)

So, when x = 0 in equation (iii)

$a = 0$

and when $x = \pm\dfrac{a}{\sqrt{2}}$ then 'a' is maximum Hence the graph between 'a' i.e. acceleration and x – axis is given as



440. A boat at anchor is rocked by waves whose crests are 100 m apart and velocity is 25 m/s. The boat bounces up once in every :

(a) 2500 s
(b) 75 s
(c) 4 s
(d) 0.25 s

UPSEE - 2006

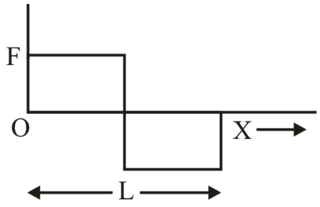
Ans. (c) : Given data, wavelength (λ) = 100m

Velocity of wave (v) = 25m/s

We know that, time $= \dfrac{\text{Wavelength}}{\text{velocity}}$

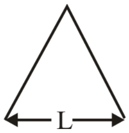
$$\therefore \quad \text{Time in one bounce} = \frac{100}{25} = 4\,\text{sec}$$

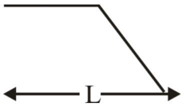
441. A person used force (F), shown in the figure to move a load with a constant velocity on a given surface.

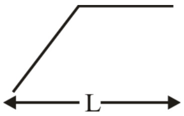


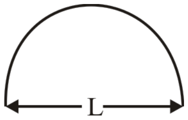
Identify the correct surface profile:

@apna_pdf

(a)


(b)


(c)


(d)


AIIMS-2006

Ans. (a) : The figure shows that the force is constant during loading and unloading. In figure (b) and (c) there are regions of constant slope. Thus no force is required in loading through those regions. But the force always has a magnitude. In figure (d), the force needs to change at every point as the inclination of the surface change at every point.]

The correct surface is option (a) where a loading force of mg sinθ is required , and mg sinθ acts in opposite direction while unloading.

442. A particle is thrown vertically upwards with a velocity of 4 ms^{-1}. The ratio of its accelerations after 1s and 2s of its motion is

(a) 2 (b) 9.8

(c) 1 (d) 4.9

AIIMS-2009

Ans. (c) : Acceleration of a motion body under gravity is always constant that is 9.8 m/s^2

So, acceleration will be same after 1s and 2s

Ratio = $\frac{9.8}{9.8} = 1$

443. A person is sitting in a lift accelerating upward Measured weight of person will be

(a) less than actual weight

(b) equal to actual weight

(c) more than actual weight

(d) none of these

DCE-2007

Ans. (c) : When the lift is accelerating upwards with an acceleration a

then N–mg = ma

∴ N = mg + ma

Therefore, the apparent weight is more than the actual weight.

444. A particle is moving in a circular path of radius 20 m such that it covers a distance $s = 2 + \frac{1}{3}t^3$, where s is in metre and t is in second. Then the acceleration of the particle after 3 seconds will be

(a) 7.2 m/s^2 (b) 3.6 m/s^2

(c) 11 m/s^2 (d) 6 m/s^2

Assam CEE-2014

Ans. (a) : Given, Radius (r) = 3m

Time = 2 sec

$$s = 2 + \frac{t^3}{3}$$

Acceleration = $\sqrt{a_t^2 + a_r^2}$ ....(i)

Where,

a_t = Tangential acceleration

a_r = Radial acceleration

Tangential acceleration (a_t) = $\frac{d^2s}{dt^2}$

$$s = 2 + \frac{1}{3}t^3$$

$$\frac{ds}{dt} = 0 + \frac{3t^2}{3}$$

$$\frac{d^2s}{dt^2} = 2t$$

$$a_{t(t=3sec)} = 6\,m/s^2$$

For radial acceleration

$$a_r = \frac{v^2}{r}$$

$$s = 2 + \frac{1}{3}t^3$$

$$\frac{ds}{dt} = v = 0 + \frac{3}{3}t^2$$

$$v = t^2$$

$$v_{t=3sec} = 9\,m/s$$

$$a_r = \frac{9 \times 9}{20} = \frac{81}{20}$$

$$a = \sqrt{6^2 + \left(\frac{81}{20}\right)^2}$$

$$a = 7.23\,m/s^2$$

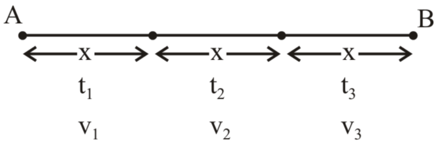
445. An object travels in a straight line one- third of the total distance with velocity v$_1$, second one-third distance with velocity v$_2$ and the rest one-third distance with velocity v$_3$. The average velocity of object will be

(a) $\frac{v_1 + v_2 + v_3}{3}$ (b) $\frac{v_1v_2 + v_2v_3 + v_3v_1}{3v_1v_2v_3}$

(c) $\sqrt{v_1v_2v_3}$ (d) $\frac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$

CG PET- 2011

Ans. (d) :



We know that,

Average speed = $\frac{\text{Total distance covered}}{\text{Total time}}$

Suppose that, each 1/3rd distance be x

Time taken to cover first, one-third distance = t_1

Time taken to cover second, one-third distance = t_2

Time taken to cover third, one-third distance = t_3

Total distance AB = 3x

Total time = $t_1 + t_2 + t_3$

@apna_pdf

So, $v_{avg} = \dfrac{3x}{t_1 + t_2 + t_3}$

Or $v_{avg} = \dfrac{3x}{\dfrac{x}{v_1} + \dfrac{x}{v_2} + \dfrac{x}{v_3}}$

Or $v_{avg} = \dfrac{3x}{\left(\dfrac{1}{v_1} + \dfrac{1}{v_2} + \dfrac{1}{v_3}\right)x}$

Or $v_{avg} = \dfrac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$

446. A particle moves in a circle of radius 30 cm. Its linear speed is given by v=2t, where t is in second and v in m/s. Find out its, radial and tangential acceleration at t=3s respectively,

(a) 220 m/s^2, 50m/s^2 (b) 100 m/s^2, 5m/s^2
(c) 120 m/s^2, 2m/s^2 (d) 110 m/s^2, 10m/s^2

CG PET- 2008

Ans. (c) : Given that,
radius of circle, r = 30 cm = 0.3m
Linear speed v = 2t, time (t) = 3s

Radial acceleration $(a_r) = \dfrac{v^2}{r} = \dfrac{(2t)^2}{r} = \dfrac{(2\times3)^2}{0.3} = \dfrac{6^2}{0.3}$

$= \dfrac{36}{0.3} = 120 \text{ m/s}^2$

Tangential acceleration $(a_t) = \dfrac{dv}{dt} = \dfrac{d}{dt}(2t) = 2\text{m/s}^2$

447. Car A starts initially with the acceleration a_1, after 2s the car B starts with acceleration a_2. If in 5th second both car travels same distance, then the ratio of a_1 and a_2 will be

(a) 5:9 (b) 5:7
(c) 9:5 (d) 9:7

CG PET- 2007

Ans. (a) : Distance travelled in nth second

$S_n = u + \dfrac{a}{2}(2n-1)$

Here, Initial velocity, u = 0
Distance travelled by car A in 5th sec.

$S_A = 0 + \dfrac{a_1}{2}(2\times5-1) = \dfrac{9a_1}{2}$

Distance travelled by car B in 5th sec.

$S_B = 0 + \dfrac{a_2}{2}(2\times3-1)$ {∵ car B starts 2s after A}

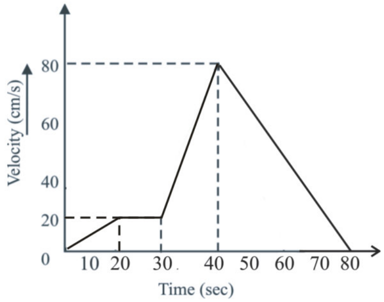
$S_B = \dfrac{5a_2}{2}$

According to the question, $S_A = S_B$

$\therefore \dfrac{9a_1}{2} = \dfrac{5a_2}{2}$

Therefore, $\dfrac{a_1}{a_2} = \dfrac{5}{9}$

448. The v-t graph of a moving object is given in figure. The maximum acceleration is



(a) 1 cm/s^2 (b) 2 cm/s^2
(c) 3 cm/s^2 (d) 6 cm/s^2

CG PET- 2007

Ans. (d) : Maximum acceleration means maximum change in velocity in minimum time interval.
Slope of v – t graph is maximum during time interval 30s to 40s

$\therefore$ Maximum acceleration (a) $= \dfrac{\Delta v}{\Delta t} = \dfrac{80-20}{40-30}$

$= \dfrac{60}{10}$

Or $a = 6 \text{ cm/s}^2$

Slope of v – t graph represents acceleration.

449. A particle under the action of a constant force moves rest up to 20s. If distance covered in first 10s is s_1 and that covered in next 10s is s_2, then

(a) $s_2 = s_1$ (b) $s_2 = 3s_1$
(c) $s_2 = 2s_1$ (d) $s_2 = 4s_1$

CG PET- 2005

Ans. (b) : Given that, u = 0
Distance covered in first 10s is S_1,

$S_1 = ut + \dfrac{1}{2}at^2$

$S_1 = 0\times t + \dfrac{1}{2}a(10)^2$

$S_1 = 50a$……… (i)

Distance covered in 20 second is S'

$S' = 0\times20 + \dfrac{1}{2}a(20)^2$

$S' = 200a$

$\therefore$ Distance travelled in last 10s

$S_2 = S' - S_1$
$= 200a - 50a$
$= 150\,a$ ……….. (ii)

Dividing equation (i) by equation (ii), we get –

$\dfrac{S_1}{S_2} = \dfrac{50a}{150a}$

$\dfrac{S_1}{S_2} = \dfrac{1}{3}$

Or $S_2 = 3S_1$

@apna_pdf

450. A person completes half of its journey with speed v_1 and rest half with speed v_2. The average speed of the person is

(a) $v = \frac{1}{2}(v_1 + v_2)$ (b) $v = \frac{2v_1v_2}{v_1 + v_2}$

(c) $v = \frac{v_1v_2}{v_1 + v_2}$ (d) $v = \sqrt{v_1v_2}$

CG PET- 2004

Ans. (b) : Let t_1 be the time taken by the person to cover first half distance

$$t_1 = \frac{s/2}{v_1} = \frac{s}{2v_1}$$

Let t_2 be the time taken by the person to cover remaining half distance

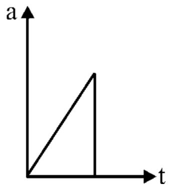
$$t_2 = \frac{s/2}{v_2} = \frac{s}{2v_2}$$

Average speed, $V_{avg} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$

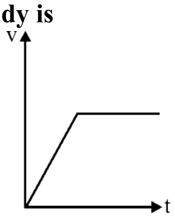
Average speed $= \frac{s}{\frac{s}{2}\left(\frac{1}{v_1} + \frac{1}{v_2}\right)}$

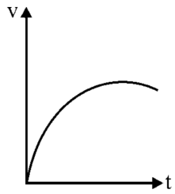
$$\boxed{V_{avg} = \frac{2v_1v_2}{v_1 + v_2}}$$

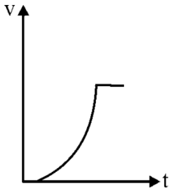
451. The acceleration-time graph of a body is shown below

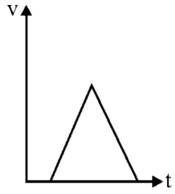


The most probable velocity-time graph of the body is

(a)


(b)


(c)


(d)


Manipal UGET-2014

Ans. (c) : The acceleration time graph from the given graph acceleration is increasing constant rate.

$\therefore \quad \frac{da}{dt} = k \quad$ (constant)

$a = kt$

$\frac{dv}{dt} = kt$

$dv = kt\,dt$

$\int dv = k\int t\,dt$

$v = \frac{kt^2}{2}$

i.e.v. is dependent on time parabolically and parabola is symmetric about v-axis and suddenly acceleration becomes zero. Velocity will be constant after some time.

452. A body starts from the origin and moves along the x-axis such that velocity at any instant is given by ($4t^3$-2t), where t is in second and velocity is in m/s. What is the acceleration of the particle, when it is 2m from the origin?

(a) 28m/s^2 (b) 22m/s^2

(c) 12 m/s^2 (d) 10 m/s^2

Manipal UGET-2014

Ans. (b) : Given that, velocity (v) = $4t^3 - 2t$

We know, acceleration (a) = $\frac{dv}{dt}$

$$a = \frac{d(4t^3 - 2t)}{dt} = 12t^2 - 2$$

We also know that

$$v = \frac{dx}{dt}$$

$$\int dx = \int v dt$$

Now

$$x = \int v dt = \int (4t^3 - 2t)dt = t^4 - t^2$$

When particle is 2m away from the origin,

$t^4 - t^2 = 2$

$t^4 - t^2 - 2 = 0$

$t^4 + t^2 - 2t^2 - 2 = 0$

$(t^2 - 2)(t^2 + 1) = 0 \qquad t = \sqrt{2}$ sec

By putting this value t = $\sqrt{2}$ in the above equation of acceleration

$a = 12t^2 - 2$

$a = 12 \times 2 - 2$

$a = 22$ m/s^2

453. A car travelling on a straight track moves with uniform velocity of v_1 for some time and with uniform velocity v_2 for the next equal time the average velocity on the car is

(a) $\frac{v_1v_2}{2}$ (b) $\frac{v_1v_2}{4}$

(c) $\frac{v_1 + v_2}{2}$ (d) $\frac{v_1 - v_2}{2}$

Manipal UGET-2013

Ans. (c) : Average velocity is defined as the total displacement travelled by the body in total interval of time.

Let each time interval be t

@apna_pdf

Displacement covered in first time interval

$d_1 = v_1 t$

Displacement covered in second time interval

$d_2 = v_2 t$

Total displacement $d = d_1 + d_2$

$= (v_1 + v_2)\,t$

Total time $t = t + t = 2t$

Average velocity $V_{avg} = \dfrac{(v_1 + v_2)t}{2t} = \dfrac{v_1 + v_2}{2}$

$$V_{avg} = \frac{v_1 + v_2}{2}$$

454. A person is sitting in a lift accelerating upwards. Measured weight of person will be

(a) less than actual weight

(b) equal to actual weight

(c) more than actual weight

(d) None of the above

Manipal UGET-2010

Ans. (c) : When the lift move upward with acceleration a then the net upward force on the person is

$R - mg = ma$

$\therefore$ Apparent weight, $R = mg + ma = m(g + a)$

So, when a lift accelerates upwards, the apparent weight of the person inside it increase.

455. A particle moves along a straight line OX. At a time t (in second), the distance x of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest?

(a) 24m (b) 40 m

(c) 56 m (d) 16 m

JCECE-2014

Ans. (c): Given,

Distance travelled by the particle $(x) = 40 + 12t - t^3$

$\therefore$ Velocity $(V) = \dfrac{dx}{dt} = 12 - 3t^2$

When particles come to rest,

$\dfrac{dx}{dt} = 0$

$V = 0$

$12 - 3t^2 = 0$

$3t^2 = 12 \Rightarrow t = 2$ sec

Hence, distance travelled by the particle at t = 2 sec

$x = 40 + 12t - t^3$

$x = 40 + 12 \times 2 - 2^3$

$x = 56$ m

456. A man slides down a light rope whose breaking strength is η times his weight. What should be his maximum acceleration so that the rope just not breaks?

(a) $g(1-\eta)$ (b) ηg

(c) $\dfrac{g}{1+\eta}$ (d) $\dfrac{g}{1-\eta}$

JCECE-2011

Ans. (a) : Let the man accelerate in upward direction -

$mg - T = ma$

$T = mg - ma$

Given,

$T = \eta\, mg$ is the maximum tension that the rope can with stand. Then,

$\eta\, mg = mg - ma$

$a = (1 - \eta)\, g$

457. The area of the acceleration-displacement curve of a body gives

(a) impulse

(b) change in momentum per unit mass

(c) change in KE per unit mass

(d) total change in energy

JCECE-2007

Ans. (c) : Area of acceleration–displacement curve gives change in KE per unit mass.

We know,

$$a = v.\frac{dv}{dx}$$

$$\underset{\substack{\downarrow \\ \textbf{Area of acceleration-} \\ \textbf{displacement curve}}}{\int_{x_1}^{x_2} a\,dx} = \int_u^v v\,dv = \left[\frac{1}{2}v^2\right]_u^v = \underset{\substack{\downarrow \\ \textbf{Change in K.E} \\ \textbf{per unit mass}}}{\frac{1}{2}\left(v^2 - u^2\right)}$$

458. If a body moves for 2 s with 15 m/s velocity towards east and then moves with 5 m/s velocity for 8 s towards north, then average velocity is :

(a) 5 m/s (b) 15 m/s

(c) 30 m/s (d) 7.5 m/s

JCECE-2006

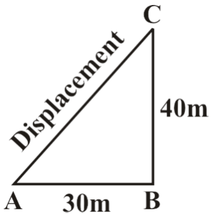
Ans. (a):

Displacement along East (AB) = 15×2

$= 30$m

Displacement along North (BC) = 5×8

$= 40$m



Thus, total displacement (AC) $= \sqrt{(30)^2 + (40)^2} = 50\,\text{m}$

Total time taken = 2 sec + 8 sec = 10 sec

Average velocity $= \dfrac{\text{Total displacement}}{\text{Total time}}$

$= \dfrac{50}{10} = 5\,\text{m/s}$

@apna_pdf

459. An object travels north with a velocity of 10 ms^{-1} and then speeds up to a velocity of 25 ms^{-1} in 5 s. The acceleration of the object in these 5 s is :

(a) 12 ms^{-2} in north direction
(b) 3 ms^{-2} in north direction
(c) 15 ms^{-2} in north direction
(d) 3 ms^{-2} in south direction

JCECE-2005

Ans. (b): Given,

$V_1 = 10 m/s, V_2 = 25 m/s, \Delta t = 5 sec$

Rate of change of velocity per unit time is defined as acceleration. So,

$$a = \frac{\Delta V}{\Delta t} = \frac{V_2 - V_1}{\Delta t} = \frac{25-10}{5}$$

$a = 3 m/s^2$ in north direction

460. If a body starts from rest and travels 110 cm in the 9th second, then acceleration of the body is:

(a) 0.13 m/s^2 (b) 0.16 m/s^2
(c) 0.18 m/s^2 (d) 0.34 m/s^2

JCECE-2003

Ans. (a) : Given, $S_9 = 110$ cm

Body starts from rest. So, u = 0

If distance travelled by the body in n^{th} second then,

$$S_n = u + \frac{1}{2} a (2n-1)$$

$$110 = 0 + \frac{1}{2} a (2 \times 9 - 1) \quad (\because n = 9)$$

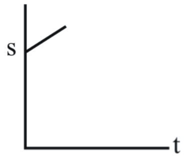
$$110 = \frac{a}{2} \times 17$$

$$a = \frac{2 \times 110}{17} \approx 13 cm/s^2$$

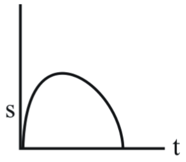
$a = 0.13 m/s^2$

461. Which one of the following represents uniform motion?

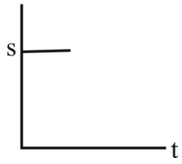
(a)



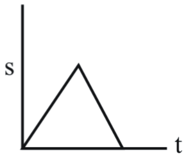
(b)



(c)



(d)



COMEDK 2014

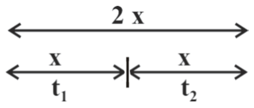
Ans. (a) : Graph (a) represents uniform motion because displacement is directly proportional to time. But initial velocity is not zero ($u \neq 0$).

462. A car covers the first half distance between two places at 40 kmph and the other half at 60 kmph. The average speed of the car is

(a) 48 kmph (b) 120 kmph
(c) 50 kmph (d) 24 kmph

COMEDK 2014

Ans. (a): Let the distance of total journey be 2x and t_1 and t_2 be the time intervals for first and second half respectively.



$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

For first half speed is given as 40 km/hr. So,

$$\text{time } (t_1) = \frac{\text{distance}}{\text{speed}} = \frac{x}{40}$$

For second half speed is given as 60 km/hr. So,

$$\text{time } (t_2) = \frac{x}{60}$$

$$\text{Average speed} = \frac{2x}{\frac{x}{40} + \frac{x}{60}} = \frac{2 \times 60 \times 40}{100}$$

$= 48$ km/hr

463. A pebble is dropped into a well of depth h. The splash is heard after time t. If c be the velocity of sound, then

(a) $t = \frac{gh^2}{cv^2}$ (b) $t = \frac{c+v}{g}$

(c) $t = \frac{c-v}{g}$ (d) $t = \sqrt{\frac{2h}{g}} + \frac{h}{c}$

COMEDK 2016

Ans. (d) : The time taken by stone to cover distance h is

$$h = \frac{1}{2} g t_1^2$$

$$t_1 = \sqrt{\frac{2h}{g}}$$

Now, the time taken by sound to cover the distance h is

$$t_2 = \frac{h}{c}$$

Total time after which the splash heard is

$$t = t_1 + t_2$$

$$t = \frac{h}{c} + \sqrt{\frac{2h}{g}}$$

464. Assertion: Velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to the time axis.

Reason: In uniform motion of an object velocity increases as the square of time elapsed.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2015

@apna_pdf

Ans. (c): In uniform motion, the object moves with uniform velocity. The magnitude of its velocity at different instant i.e at t = 0, t = 1 sec, t = 2 sec .... will always be constant in uniform motion along a straight path is a straight line parallel to time axis.

465. Assertion: A body can have acceleration even if its velocity is zero at a given instant of time.

Reason: A body is numerically at rest when it reverses its direction.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-1998

Ans. (a): When body going vertically upward reaches at the highest point. Then, it is numerically at rest when it reverses its direction. At the highest point of motion, its velocity is zero but its acceleration is equal to acceleration due to gravity.

466. Assertion: Retardation is directly opposite to the velocity.

Reason: Retardation is equal to the time rate of decrease of speed.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2002

Ans. (a): Acceleration is the time rate of increase of velocity but retardation is negative of acceleration.

$$\text{Retardation} = \frac{\text{Decrease velocity}}{\text{Time}}$$

Retardation is the rate of decrease of velocity with time and also retardation acts in the direction opposite to that of velocity.

467. The coordinates of a moving particle at any time t are given by x = a t^2 and y = b t^2. The speed of the particle is

(a) $2t(a+b)$ (b) $2t\sqrt{(a^2+b^2)}$
(c) $2t\sqrt{(a^2-b^2)}$ (d) $\sqrt{(a^2+b^2)}$

AIIMS-2012

Ans. (b): Given, $x = at^2$ and $y = bt^2$

$$\text{Velocity along x – axis } v_x = \frac{dx}{dt} = 2at$$

$$\text{Velocity along y – axis } v_y = \frac{dy}{dt} = 2bt$$

Magnitude of velocity of the particle –

$$v = \sqrt{(v_x)^2 + (v_y)^2} = 2t\sqrt{a^2+b^2}$$

468. The position (x) of a particle at any time (t) is given by

$$\mathbf{x(t) = 4t^3 - 3t^2 + 2}$$

The acceleration and velocity of the particle at any time t = 2 sec are respectively

(a) 16 ms^{-2} and 22 ms^{-1} (b) 42 ms^{-2} and 36 ms^{-1}
(c) 48 ms^{-2} and 36 ms^{-1} (d) 12 ms^{-2} and 25 ms^{-1}

AIIMS-2009

Ans. (b) : Given,

$$x(t) = 4t^3 - 3t^2 + 2$$

$$v = \frac{dx}{dt} = 12t^2 - 6t$$

v at t = 2 sec,

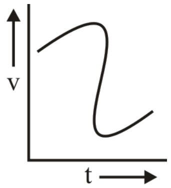
$$v = 12(2)^2 - 6(2) = 36 \text{ m/s}$$

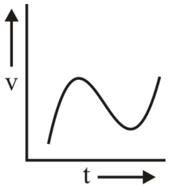
And $a = \frac{dv}{dt} = 24t - 6$

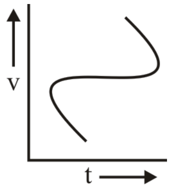
a at t = 2 sec,

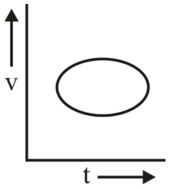
$$a = 24 \times 2 - 6 = 42 \text{ m/s}^2$$

469. Which of the following velocity-time graphs shown a realistic situation for a body in motion?

(a)


(b)


(c)


(d)


AIIMS-2004, 2007

Ans. (b) : Time cannot reverse itself if or it can only go forward. In graph (a) and (d) some portion of graph has show time changing in such a way or time is going from high volume to law volume which is not practical. In realistic situation, the body can't have more than one velocity at the same instant.

470. The relation between time and distance of a moving body is t = 5x^2 + 7x + 8. The acceleration of the body will be–

(a) – $10v^3$ (b) –10 v^2
(c) $10v^3$ (d) $10v^2$

BCECE-2016

@apna_pdf

Ans. (a) : Given,

$$t = 5x^2 + 7x + 8$$

Differentiating both side w.r.t. x

$$\frac{dt}{dx} = 10x + 7$$

$$\frac{dx}{dt} = v = \frac{1}{10x+7} \text{ ....(i)} \qquad \left[\because \frac{dx}{dt} = v\right]$$

$\therefore$ Acceleration (a) = $\dfrac{dv}{dt}$

$$\frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt} = v \times \frac{dv}{dx}$$

$$\frac{dv}{dt} = v.\left[\frac{0-10}{(10x+7)^2}\right]$$

$$\left(\text{Using formula } \frac{d}{dx}\frac{Nr}{Dr} = \frac{Nr\frac{d}{dx}Dr - Dr\frac{d}{dx}Nr}{(Nr)^2}\right)$$

$a = v.v^2(-10)$ using equation (i)

$a = -10v^3$

471. In a car race, car A takes a time t less than car B at the finish and passes the finishing point with speed v more than that of the car B. Assuming the both the cars starts from rest and travel with constant accelerations a_1 and a_2 respectively. So, the value of v will be-

(a) $(\sqrt{a_1/a_2})t$ (b) $(\sqrt{a_2/a_1})t$

(c) $(a_1\sqrt{a_2})t$ (d) $(\sqrt{a_1 a_2})t$

BCECE-2015

Ans. (d) : Let,

$u = 0$

A takes t_1 sec

B takes $(t_1 + t)$ sec

So, $t_2 - t_1 = t$ ....(i)

$v_1 - v_2 = v$ ....(ii)

$S_1 = S_2 = S$

$$S = \frac{1}{2}a_1 t_1^2$$

$$t_1 = \sqrt{\frac{2S}{a_1}} \text{ ....(iii)}$$

And,

$$S = \frac{1}{2}a_2 t_2^2$$

$$t_2 = \sqrt{\frac{2S}{a_2}} \text{ ....(iv)}$$

Now,

$$v_1^2 = 2a_1 S \quad \text{and} \quad v_2^2 = 2a_2 S$$

$$v_1 = \sqrt{2a_1 S} \qquad v_2 = \sqrt{2a_2 S}$$

Dividing equation (i) by equation (ii)

$$\frac{v}{t} = \frac{v_1 - v_2}{t_2 - t_1}$$

$$= \frac{\sqrt{2a_1 S} - \sqrt{2a_2 S}}{\sqrt{\frac{2S}{a_2}} - \sqrt{\frac{2S}{a_1}}}$$

$$= \frac{\sqrt{a_1} - \sqrt{a_2}}{\frac{1}{\sqrt{a_2}} - \frac{1}{\sqrt{a_1}}} = \frac{\sqrt{a_1} - \sqrt{a_2}}{\frac{\sqrt{a_1} - \sqrt{a_2}}{\sqrt{a_1 a_2}}}$$

$$\frac{v}{t} = \sqrt{a_1 a_2}$$

$$v = \left(\sqrt{a_1 a_2}\right)t$$

472. A point initially at rest moves along x-axis. Its acceleration varies with time as $a = (6t+5)m/s^2$. If it starts from origin, the distance covered in 2s is–

(a) 20m (b) 18m

(c) 16m (d) 25m

BCECE-2008

Ans. (b): Given,

$$a = \frac{dv}{dt} = 6t + 5$$

$$dv = (6t+5)\,dt$$

Integration, we get

$$\int_0^v dv = \int_0^t (6t+5)\,dt$$

$$v = \left(\frac{6t^2}{2} + 5t\right)$$

Again $v = \dfrac{ds}{dt}$

$$\therefore \quad ds = \left(\frac{6t^2}{2} + 5t\right)dt$$

Integrating again, we get

$$\int_0^s ds = \int_0^t \left(\frac{6t^2}{2} + 5t\right)dt$$

$$\therefore \quad s = \frac{3t^3}{3} + \frac{5t^2}{2}$$

When, $t = 2$

$$s = 3 \times \frac{2^3}{3} + \frac{5 \times 2^2}{2}$$

$$s = 3 \times \frac{8}{3} + \frac{5 \times 4}{2}$$

$s = 8 + 10 = 18$ meter

473. A particle moving with a uniform acceleration travels 24 m and 64 m in the first two consecutive interval of 4s each. Its initial velocity will be–

(a) 5 m/s (b) 3 m/s

(c) 1 m/s (d) 4 m/s

BCECE-2007

@apna_pdf

Ans. (c) : From equation of motion

$$s = ut + \frac{1}{2}at^2$$

Where s is displacement u is initial velocity a is acceleration and t is time

When, s = 24 m, t = 4 sec

$$24 = 4u + \frac{1}{2}a(4)^2$$

$$24 = 4u + 8a$$

$$6 = u + 2a \qquad ....(i)$$

When body travels a total distance of

s = 24 + 64 = 88 m in t = 8 sec

Now, $s = ut + \frac{1}{2}at^2$

$$88 = 8u + \frac{1}{2}a(8)^2$$

$$88 = 8u + 32a$$

$$11 = u + 4a \qquad ...(ii)$$

From equation (i) and (ii), we get

$$5 = 2a$$

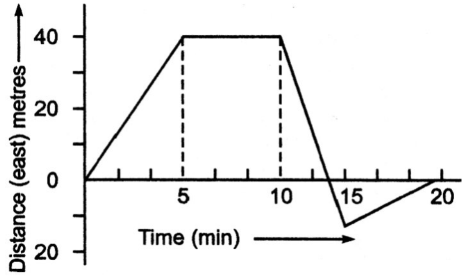
$$a = \frac{5}{2} m/s^2$$

Putting value of a in equation (i)

$$6 = u + 2 \times \frac{5}{2}$$

$$u = 1 \text{ m/s}$$

474. A boy begins to walk eastward along a street in front of his house, and the graph of his displacement form home is shown in the following figure. His average velocity for the whole time interval is equal to :



(a) 8m/min (b) 6 m/min
(c) 8/3 m/min (d) 2 m/min

BCECE-2006

Ans. (b):

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

Total distance covered = 40 + 40 + 20 + 20 = 120m

Total time taken = 20 minutes

$$\text{Average speed} = \frac{120m}{20min} = 6 \text{ m/min}$$

475. The displacement of a particle moving in a straight line is given by $x = 2t^2 + t + 5$ where x is expressed in metre and t in second. The acceleration at t = 2 s is

(a) 4 ms^{-2} (b) 8 ms^{-2}
(c) 10 ms^{-2} (d) 15 ms^{-2}

EAMCET-1995

Ans. (a) : Given,

$$X = 2t^2+t+5$$

$$\frac{dx}{dt} = 4t+1$$

$$\frac{d^2x}{dt^2} = 4 = \frac{d^2x}{(dt^2)_{t=5sec}} = 4m/s^2$$

476. A motor cycle is travelling on a curved track of radius 500 m. If the coefficient of friction between the tyres and road is 0.5, with g = 10 ms^{-2}. What should be the maximum speed to avoid skidding?

(a) 500 ms^{-1} (b) 250 ms^{-1}
(c) 50 ms^{-1} (d) 10 ms^{-1}

EAMCET-1996

Ans. (c) : Given,

r = 500 m

$\mu = 0.5$

g = 10 m/s^2

velocity is currved road track given by

$$V = \sqrt{\mu rg}$$

$$V = \sqrt{0.5 \times 500 \times 10}$$

$$V = 50 \text{ m/s}$$

477. The direction of velocity and acceleration of a projectile at the highest point on the trajectory are

(a) parallel to each other
(b) antiparallel to each other
(c) perpendicular to each other
(d) no specific relationship exist between them

EAMCET-1996

Ans. (c) : The direction of velocity is always tangent to the path so at the top of trajectory it is horizontal direction and acceleration due to gravity is always in vertically downward direction.
Hence, v and g are perpendicular to each other.

478. A particle is moving east wards with a velocity of 15 ms^{-1}. In a time of 10 s, the velocity changes to 15 ms^{-1} northwards. Average acceleration during this time is (in ms^{-2})

(a) $\frac{3}{\sqrt{2}}$ north-east (b) $3\sqrt{2}$ north-east

(c) $\frac{3}{\sqrt{2}}$ north-west (d) $3\sqrt{2}$ north-west

EAMCET-1997

Ans. (a) : Given that,

$\Delta t = 10$ sec

$$v_R = \sqrt{(v_N)^2 + (v_E)^2}$$

$$v_R = \sqrt{(15)^2 + (15)^2}$$

$$v_R = \sqrt{225 + 225}$$

@apna_pdf

$v_R = \sqrt{450}$

$v_R = 15\sqrt{2}\ \text{m/s NE}$

Average acceleration will be $= \dfrac{\text{velocity}}{\text{time}}$

$$= \frac{15\sqrt{2}}{10} = \frac{3\sqrt{2}}{2} = \frac{3}{\sqrt{2}}\ \text{N.E.}$$

479. A car starts from rest, attains a velocity of 36 kmh^{-1} with an acceleration of 0.2 ms^{-2}, travels 9 km with his uniform velocity and then comes to half with a uniform deceleration of 0.1 ms^{-2}. The total time of travel of the car is

(a) 1050 s (b) 1000 s

(c) 950 s (d) 900 s

EAMCET-1998

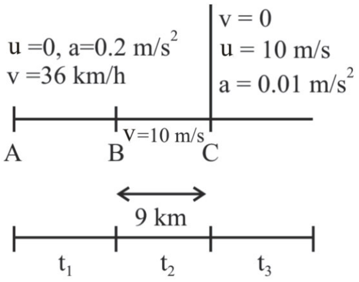
Ans. (a) : Using the equation of motion

Case–I

$v = u + at$

$10 = 0 + 0.2 \times t_1$

$t_1 = 50$ sec



Case– II

$$\text{Time} = \frac{\text{distance}}{\text{velocity}}$$

$$t_2 = \frac{9000}{10}$$

$t_2 = 900$

Case – III

$v = 0,\ u = 10,\ a = 0.1,\ t_3 = ?$

using the equation of motion,

$v = u + at$

$0 = 10 + (-0.1) \times t_3$

$t_3 = 100$ sec

Total time of travel of the car $t = t_1 + t_2 + t_3$

$= 50 + 900 + 100$

$t = 1050$ second

480. A car starts from rest and travels with uniform acceleration α, for some time and then with uniform retardation β and comes to rest. If the total time of car is t, the maximum velocity attained by it is given by

(a) $\dfrac{\alpha\beta}{(\alpha+\beta)}t$ (b) $\dfrac{1}{2}\dfrac{\alpha\beta}{(\alpha+\beta)}t^2$

(c) $\dfrac{\alpha\beta}{(\alpha-\beta)}t$ (d) $\dfrac{1}{2}\dfrac{\alpha\beta}{(\alpha-\beta)}t^2$

EAMCET-1999

Ans. (a) : Acceleration (a) = α m/s^2

Initial speed u = 0 m/s

Let time be t_1 sec

Equation of motion

$v = u + at$

$v = 0 + \alpha t_1$

$t_1 = v/\alpha$ sec

Retardation $a = -\beta$ m/s^2

Initial passed 'u' is equal to the final velocity with acceleration 'α'

$u = \alpha t_1 = v$

Final velocity v = 0 m/s

Let the time be t_2 sec

From equation, $v = u + at$

$0 = \alpha t_1 + (-\beta)\, t_2$

$-\alpha t_1 = -\beta t_2 \qquad (v = \alpha t_1)$

$$v = \beta t_2 \Rightarrow t_2 = \frac{v}{\beta}$$

Total time of motion $t = t_1 + t_2$

$$t = \frac{v}{\alpha} + \frac{v}{\beta} \Rightarrow t = v\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)$$

$$t = v\left(\frac{\alpha+\beta}{\alpha\beta}\right)$$

$$v = \frac{\alpha\beta t}{\alpha+\beta}$$

The maximum velocity attained by the car

$$\boxed{v = \frac{\alpha\beta t}{\alpha+\beta}}$$

481. A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain way. He throws the umbrella and starts running at 10 kmh^{-1}. He finds that raindrops are hitting his head vertically. The actual speed or raindrops is

(a) 20 kmh^{-1} (b) $10\sqrt{3}$ kmh^{-1}

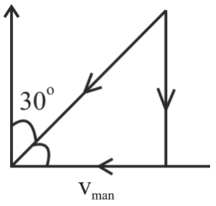
(c) $20\sqrt{3}$ kmh^{-1} (d) 10 kmh^{-1}

EAMCET-2006

Ans. (a) : When the man is at rest with respect to the ground, the rain comes to him at an angle 30° with the vertical. This is the direction of the velocity of raindrops with respect to the ground. The situation when the main run is showing figure.

@apna_pdf

v_{rg}= velocity of rain drops with respect to ground.



v_{man} = Velocity of man = 10 km/h

Hence cos θ =

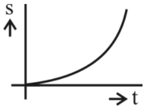
$$\cos 60^o = \frac{10}{v_{rg}}$$

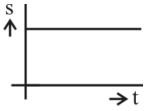
$$\frac{1}{2} = \frac{10}{v_{rg}}$$

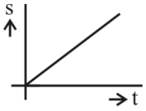
$$\Rightarrow \quad \boxed{v_{rg} = 20\text{km/h}}$$

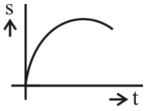
Hence, velocity of rain drops with respect to the ground 20 km/h.

482. A body is travelling in a straight line with a uniformly increasing speed. Which one of the plot represents the changes in distance (*s*) travelled with time (*t*) ?

(a)


(b)


(c)


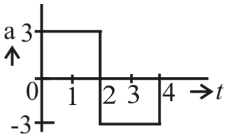
(d)


DCE-2009

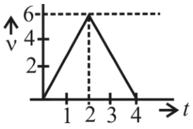
Ans. (a) : $s = \frac{1}{2}at^2$

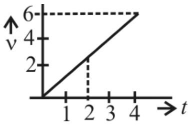
(parabola symmetric with displacement axis)

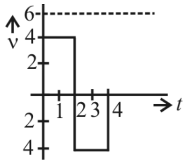
483. A particle starts from rest at t = 0 and undergoes an acceleration a in ms^{-2} with time t in seconds which is as shown

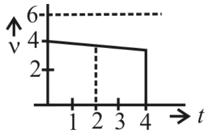


Which one of the following plot represents velocity v in ms^{-1} versus time *t* in seconds ?

(a)


(b)


(c)


(d)


DCE-2009

Ans. (a) : We know

v = u + at

∴ v = 3t

also v when t = 2 s is

v = 6 m/s

for the second stage motion,

u = 6 m/s

a = –3m/s^2

t = 2 s

v = 6 – (3 × 2) = 0 m/s

484. A bullet moving with a velocity of $30\sqrt{2}$ m/s is fired into a fixed target. It penetrated into the target to the extent of S meters. If the same bullet is fired into a target of thickness $\frac{S}{2}$ meters and of the same material with the same velocity, the bullet comes out of the target with velocity

(a) $10\sqrt{2}$ m/s
(b) 20 m/s
(c) 30 m/s
(d) $20\sqrt{2}$ m/s

AP EAMCET(Medical)-2014

Ans. (c) : Given,

$u = 30\sqrt{2}$ m/s

Distance = S m

Let a be the acceleration of the bullet according to the first condition, (v = 0)

Using the equation of motion

$v^2 = u^2 - 2as$

$0 = 900 \times 2 - 2as$

$$a = \frac{900}{s} m/s^2$$

For second condition,

$v^2 = u^2 - 2as$

$$= \left(30\sqrt{2}\right)^2 - 2\times\frac{900}{S}\times\frac{S}{2} = 1800–900$$

$v^2 = 900$

$v = \sqrt{900}$

$v = 30\,m/s$

@apna_pdf

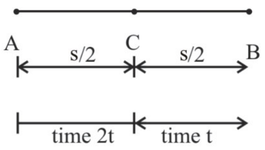
485. A vehicle moving with a constant acceleration form A to B in a straight line AB, has velocities 'u' and 'v' at A and B respectively. C is the mid point of AB. If time taken to travel from A to C is twice the time taken to travel from C to B then the velocity of the vehicle 'v' at B is.

(a) 5u (b) 6u

(c) 7u (d) 8u

AP EAMCET(Medical)-2015

Ans. (c) : According to question can be drawn as for motion from A to C



$$\frac{s}{2} = ut + \frac{1}{2}a\times(2t)^2 = 2ut + 2at^2$$

Also for motion from C to B (let initial velocity be v)

$$\frac{s}{2} = (u+2at)t + \frac{1}{2}at^2 \qquad (\therefore v_1 = u + 2at)$$

$$= ut + 2at^2 + \frac{1}{2}at^2$$

Now,

$$2ut + 2at^2 = ut + 2at^2 + \frac{1}{2}at^2$$

$$ut = \frac{1}{2}at^2$$

$$\Rightarrow \quad u = \frac{1}{2}at$$

For over all motion

$$v = u + 3at$$

$$= \frac{at}{2} + 3at$$

$$= \frac{7at}{2} \qquad \left(\therefore u = \frac{at}{2}\right)$$

$$v = 7u$$

486. The average velocity of a particle moving with constant acceleration a and initial velocity u in a straight line first t seconds is :

(a) $u+\frac{1}{2}at$ (b) $\frac{u}{2}$

(c) $u + at$ (d) $\frac{u+at}{2}$

AP EMCET(Medical)-2011

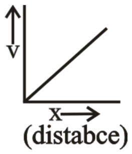
Ans. (a) :

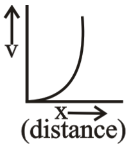
$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{total time}}$$

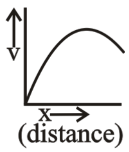
$$= \frac{ut+\frac{at^2}{2}}{t} = \frac{2ut+at^2}{2\times t} = \frac{t(2u+at)}{2t}$$

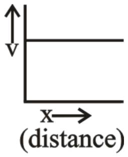
$$v_{avg} = u+\frac{1}{2}at$$

487. If an object is dropped from rest, then changes in its velocity (V) is shown by

(a)


(b)


(c)


(d)


AP EMCET(Medical)-2011

Ans. (c) : According question

$$u = 0$$

$$\because v^2 = u^2 + 2gs$$

$$\therefore v^2 = 2gs$$

This equation is like parabola equation.

488. A system consists of two identical particles. One particle is at rest and the other particle has an acceleration a. the centre of mass of the system has an acceleration of:

(a) 2a (b) a (c) $\frac{a}{2}$ (d) $\frac{a}{4}$

AP EAMCET(Medical)-2002

Ans. (c) :A system consist of two identical particles. one particle is at rest and the other particle has an acceleration a. The centre of mass of the system has an acceleration of a/2.

Acceleration of centre of mass of a two particle system is given as

$$\vec{a}_{cm} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1 + m_2} \text{ …….. (i)}$$

According to the question,

$$m_1 = m_2 = m$$

$$a_1 = 0,\ a_2 = a$$

Substituting these value in equation (i) we,

$$\vec{a}_{cm} = \frac{m\times 0 + m\vec{a}}{2m} = \frac{a}{2}$$

489. The average velocity of a body moving with uniform acceleration after travelling a distance of 3.06m is 0.34 ms^{-1}. If the change in velocity of the body is 0.18 ms^{-1}, during this time its uniform acceleration is:

(a) 0.01ms^{-2} (b) 0.02ms^{-2}

(c) 0.03ms^{-2} (d) 0.04ms^{-2}

AP EAMCET(Medical)-2000

Ans. (b) : Given that,

$$\text{Average velocity of body} = \frac{v+u}{2} = 0.34$$

Change in velocity = v – u = 0.18 m/sec

$v - u = 0.18$ …(i)

$v + u = 0.68$ …(ii)

@apna_pdf

From equation (i) and (ii)

$2v = 0.86$

$v = 0.43$ m/sec

Value of v put on equation (i)

$0.43 - u = 0.18 \Rightarrow u = 0.43 - 0.18$

$v^2 = u^2 + 2as \qquad = 0.25$ m/sec

$(0.43)^2 = (0.25)^2 + 2a \times 3.06$

$$a = \frac{(0.43)^2 - (0.25)^2}{2 \times 3.06} = \frac{(0.43 - 0.25)(0.43 + 0.25)}{2 \times 3.06}$$

$$a = \frac{(0.68) \times (0.18)}{2 \times 3.06} = \frac{0.1224}{6.12}$$

$a = 0.02$ m/sec^2

During this time its uniform acceleration is 0.02 m/sec^2

490. A car travelling on a straight track moves with uniform velocity of v_1 for same time and with uniform velocity v_2 of next equal time. The average velocity is given by :

(a) $\sqrt{v_1 v_2}$ (b) $\frac{v_1 + v_2}{2}$

(c) $\left(\frac{1}{v_1} + \frac{1}{v_2}\right)$ (d) $\left(\frac{1}{v_1} + \frac{1}{v_2}\right)^{-1}$

AP EAMCET(Medical)-1998

Ans. (b) : Given that,

- Uniform velocity of A car = V_1

Time = t

- Then with velocity V_2 for time t the displacement in time 2t sec.

$d_1 + d_2 = d$

$d = v_1 t + v_2 t$ [∵ distance = velocity time]

$d = (v_1 + v_2)\, t$

So, Average velocity = $\frac{\text{total distance}}{\text{total time}}$

$$= \frac{(v_1 + v_2)t}{2t} = \frac{v_1 + v_2}{2}$$

491. The reaction time for a car driver is 0.9s. If the car travelling initially with 36 km/h is stopped by the driver after observing a signal by the deceleration of 5m/s^2, the total distance travelled by the car before coming to rest is:

(a) 19 m (b) 9 m

(c) 10 m (d) 28 m

AP EAMCET(Medical)-1997

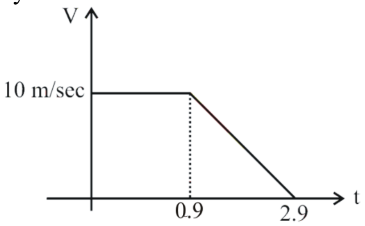
Ans. (a) : Given that

Initial velocity, u = 36 km/s

$$u = 36 \times \frac{5}{18}$$

= 10 m/sec

Final velocity v = 0



$v = u - at$

$0 = 10 - 5t$

$t = \frac{10}{5}$

$t = 2$ sec

$S_1 = ut + \frac{1}{2}at^2$

$= 10 \times 2 + \frac{1}{2}(-5)(2)^2$

$= 20 - 10$

$= 10$

Distance covered within reaction time, $S_1 = ut$

$= 10 \times 0.9$

$= 9$ m

So, total distance, $s = s_1 + s_2$

$= 10 + 9$

$= 19$ m

492. The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will

(a) Decrease with time

(b) Be independent of α and β

(c) Drop to zero when α = β

(d) Increase with time

JIPMER-2016

Ans. (d): Given,

$x = ae^{-\alpha t} + be^{\beta t}$ ....(i)

Differentiating eqn (i), with respect to time (t)

$$\frac{dx}{dt} = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$$

$v = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$

Differentiating again

$$\frac{dv}{dt} = a\alpha^2 e^{-\alpha t} + b\beta^2 e^{\beta t} > 0$$

Thus, velocity of the particle (v) will always increase with time.

493. A person walks along a straight road from his house to a market 2.5 km away with a speed of 5 km/h and instantly turns back and reaches his house with a speed of 7.5 km/h. The average speed of the person during the time interval 0 to 50 min is (in m/s)

@apna_pdf

(a) $4\frac{2}{3}$ (b) $\frac{5}{3}$

(c) $\frac{5}{6}$ (d) $\frac{1}{3}$

AP EAMCET -2014

Ans. (b) : Given,

Total time = 50 minutes = 50×60 = 3000 sec

Total distance = 2.5 + 2.5 = 5 km = 5000 m

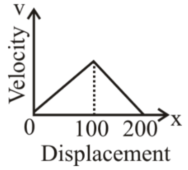
$\therefore$ Average speed of the person = $\frac{\text{Total distance}}{\text{Total time}}$

$$V_{avg} = \frac{5000}{3000} = \frac{5}{3}$$

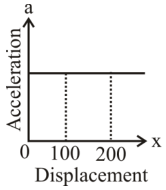
$$\boxed{V_{avg} = \frac{5}{3}}$$

So, average speed of the person during the time interval 0 to 50 is 5/3 m/s

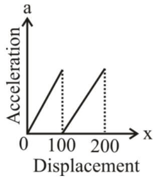
494. Velocity (v) versus displacement (x) plot of a body moving along a straight line is as shown in the graph. The corresponding plot of acceleration (a) as a function of displacement (x) is



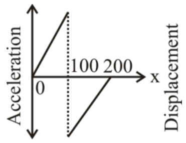
(a)



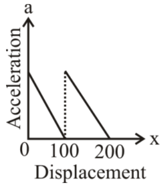
(b)



(c)

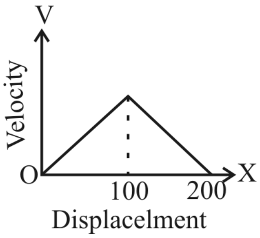


(d)



AP EAMCET -2014

Ans. (c) :



From the given graph,

equation of velocity, V = Kx ....(i)

$$\therefore \frac{dv}{dt} = K.v \quad (\text{from the equation (i)})$$

$$= K(Kx) = K^2x$$

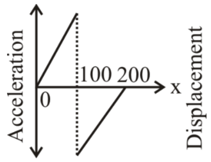
We know that, $a = \frac{dv}{dt} = k^2x$

$$v = -Kx + v_0$$

$$\therefore \frac{dv}{dt} = -Kv = -K(-Kx + v_0)$$

$$a = K^2x - Kv_0 \quad .....(i)$$

So, as per equation (ii) the shape of a–x graph is as,



495. A bus moving on a level road with a velocity v can be stopped at a distance of x, by the application of a retarding force F. The load on the bus is increased by 25% by boarding the passengers. Now, if the bus is moving with the same speed and if the same retarding force is applied, the distance travelled by the bus before it stops is

(a) 1.25 x (b) x

(c) 5x (d) 2.5x

AP EAMCET -2014

Ans. (a) : Given data, $S_1 = x$ and $m_1 = m$

$$\therefore \quad m_2 = m + \frac{25}{100}(m) = \frac{5m}{4}$$

We know that,

$v^2 - u^2 = 2a\,s$

$$o - u^2 = -2\left(\frac{F}{m}\right).S$$

$$u^2 = 2\frac{F.S}{m} \Rightarrow m = \frac{2F.S}{u^2}$$

$$\therefore m \propto s \text{ i.e } \frac{m_1}{m_2} = \frac{s_1}{s_2} \quad ....(i)$$

Now, by putting given data in equation (i)

$$\frac{m}{\frac{5m}{4}} = \frac{x}{s_2}$$

$$s_2 = \frac{5x}{4} = 1.25x$$

$s_2 = (1.25x)$

496. A man running at a speed of 5 km/h, find that the rain falls vertically. When he stops running, he finds that the rain is falling at an angle of 60° with the horizontal. The velocity of rain with respect to running man is

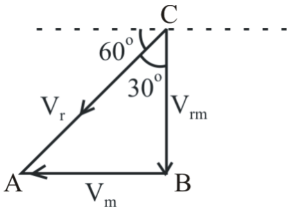
(a) $\frac{5}{\sqrt{3}}$ km/h (b) $\frac{5\sqrt{3}}{2}$ km/h

@apna_pdf

(c) $\frac{4\sqrt{3}}{2}$ km/h   (d) $5\sqrt{3}$ km/h

AP EAMCET -2015

Ans. (d) : By figure,



In ΔACB

$$\tan 30^\circ = \frac{V_m}{V_{rm}}$$

$$\frac{1}{\sqrt{3}} = \frac{5}{V_{rm}}$$

or $\boxed{V_{rm} = 5\sqrt{3}\text{ kmph}}$

Hence, option (d) is correct.

497. Displacement (x) of a particle is related to time (t) as $x = at + bt^2 - ct^3$ Where a, b and c are constants of the motion. The velocity of the particle when its acceleration is zero is given by

(a) $a+\frac{b^2}{c}$ (b) $a+\frac{b^2}{2c}$

(c) $a+\frac{b^2}{3c}$ (d) $a+\frac{b^2}{4c}$

AMU-2008, 2009

Ans. (c) : Given that,

$$x = at + bt^2 - ct^3$$

Find out $\vec{v}$

So,

$$v = \frac{dx}{dt} = a + 2bt - 3ct^2 \text{ ——(i)}$$

$$a = \frac{dv}{dt} = 2b - 6ct = 0 \text{ (According question)}$$

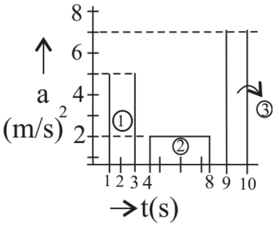
$$\Rightarrow 2b = 6ct$$

$$t = \frac{b}{3c} \text{ Put equation (i)}$$

$$v = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b^2}{9c^2}\right)$$

$$v = a + \frac{2b^2}{3c} - \frac{b^2}{3c} = a + \frac{b^2}{3c}$$

498. The figure shows a particle moving along x-axis subjected to three periods of acceleration (a). Rank the periods to the increase they produce in the particle velocity greatest first



(a) ②>①>③

(b) ②>③>①

(C) ①>③>②

(d) ①>②>③

AMU-2007

Ans. (d) : According the first law of motion

$v = u+at$

$\because$ $u = 0$ [Area under acceleration time graph

$\therefore$ $v = at$ given velocity]

So, particle 1, 2, 3 velocity

$V_1 = 5\times(3–1) = 10$ m/s

$V_2 = (8–4)\times2 = 8$ m/s

$V_3 = (10–9)\times7 = 7$m/s

Now,

$V_1>V_2>V_3$

①>②>③

499. The position x (in meters) of a particle on the x–axis is given by $x = 5t^3 + 3t^2–9$, where t is the time in seconds. What is the acceleration of the particle at t = 2 seconds (in m/s^2) ?

(a) 31   (b) 66

(c) 29   (d) 75

AMU-2007

Ans. (b) : Given,

$$x = 5t^3 + 3t^2 - 9$$

$$v = \frac{dx}{dt} = 15t^2 + 6t - 0$$

$$\frac{d^2x}{dt^2} = \frac{dv}{dx} = a = 30t + 6$$

Now, acceleration at

$t = 2$ sec,

$a = 30 \times 2 + 6$

$a = 66$ m/sec^2

500. The displacement x of a body varies with time as

$$x = -\frac{1}{3}t^2 + 16t + 3$$

Where x is in metres and t is in seconds. The time taken by the body to come to rest is

(a) 12 s   (b) 24 s

(c) 30 s   (d) 36 s

AMU-2016

@apna_pdf

Ans. (b): Given,

$$x = -\frac{1}{3}t^2 + 16t + 3$$

$$\frac{dx}{dt} = v = -\frac{2}{3}t + 16$$

$$v = -\frac{2}{3}t + 16$$

When the body comes to rest then

$$v = 0$$

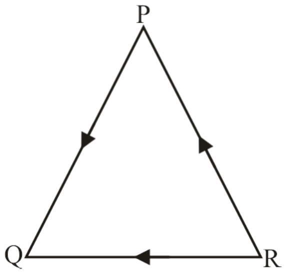
i.e. $-\frac{2}{3}t + 16 = 0$

$$-2t + 48 = 0$$

$$2t = 48$$

$$t = 24 \text{ sec}$$

501. Three particles P, Q and R are at rest at the vertices of an equilateral triangle of side s. Each of the particles starts moving with constant speed v m s^{-1}. P is moving along PQ, Q along QR and R along RP. The particles will meet each other at time t given by

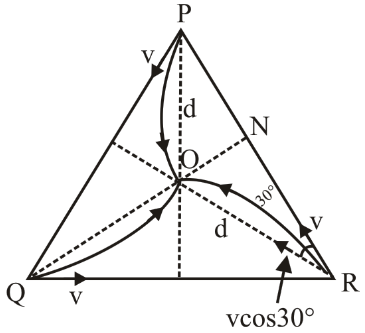


(a) $\frac{s}{v}$ (b) $\frac{3s}{v}$

(c) $\frac{3s}{2v}$ (d) $\frac{2s}{3v}$

AMU-2016

Ans. (d) :



By symmetry, all the three particles P, Q and R at the vertices of an equilateral triangle will meet at O, the centroid of the triangle while following the curved path shown in figure.

The initial distance of each particle from the centroid O is

d = PO = QO = RO

From Δ PNO, $\cos 30° = \frac{PN}{PO}$

$$PO = \frac{PN}{\cos 30°} = \frac{s/2}{\sqrt{3}/2} \quad \left(\text{as } PN = \frac{1}{2}PQ = \frac{s}{2}\right)$$

$$PO = d = \frac{s}{\sqrt{3}}$$

The component of velocity towards O is

$$v_1 = v\cos 30° = v\left(\frac{\sqrt{3}}{2}\right)$$

∴ the time of meeting is, $t = \frac{d}{v_1} = \frac{s/\sqrt{3}}{v\left(\sqrt{3}/2\right)}$

$$t = \frac{2s}{3v}$$

502. Two cars are in a race. The white car passed the finishing point with a velocity v m s^{-1} more and took time t sec less than the red car. If both the cars start from rest and travel with constant accelerations a_w and a_r respectively, $\frac{v}{t}$ is given

(a) $a_w a_r$ (b) $\sqrt{\frac{a_w}{a_r}}$

(c) $\sqrt{a_w a_r}$ (d) $\sqrt{\frac{a_r}{a_w}}$

AMU-2016

Ans. (c) : Let white car takes t_1 second, then according to the question red car will take $(t_1 + t)$ seconds.

Further let v_1 be the velocity of red car at finishing point, then the velocity of white car will be $(v_1 + v)$

For white car,

$$v_1 + v = a_w t_1 \quad \ldots(i)$$

For red car,

$$v_1 = a_r(t_1 + t) \quad \ldots(ii)$$

Putting the value of v_1 in equation (i) we have,

$$v = (a_w - a_r)t_1 - a_r t \quad \ldots(iii)$$

∵ Total distance covered by both the cars is equal.

∴ $S_w = S_r$

$$\frac{1}{2}a_w t_1^2 = \frac{1}{2}a_r(t_1 + t)^2$$

$$\Rightarrow \frac{1}{2}a_w t_1^2 = a_r t_1^2 + \frac{1}{2}a_r t^2 + a_r t_1 t$$

$$(a_w - a_r)t_1^2 - 2a_r t t_1 - \frac{1}{2}a_r t^2 = 0$$

$$t_1 = \frac{\sqrt{a_r}\, t}{\sqrt{a_w} - \sqrt{a_r}}$$

@apna_pdf

Putting the value of t_1 in equation (iii), we get

$$v = \left(\sqrt{a_w . a_r}\right)t$$

$$\frac{v}{t} = \sqrt{a_w . a_r}$$

503. Starting from origin, a body moves along x-axis. Its velocity at any time is given by $v = 4t^3 - 2t\ ms^{-1}$.

Acceleration of the particle when it is 2 m away from the origin is

(a) $28\ m\ s^{-2}$ (b) $12\ m\ s^{-2}$

(c) $22\ m\ s^{-2}$ (d) $14\ m\ s^{-2}$

AMU-2016

Ans. (c): Given data

Velocity of body at instant time $(V_t) = 4t^3 - 2t$

Now,

Time required to travel 2m from origin.

$$\frac{ds}{dt} = 4t^3 - 2t \qquad \left(v_t = \frac{ds}{dt}\right)$$

$$\Rightarrow \quad ds = \left(4t^3 - 2t\right)dt$$

Integrating on both sides we get,

$$\Rightarrow \quad \int ds = \int \left(4t^3 - 2t\right)dt$$

$$\Rightarrow \quad s = t^4 - t^2$$

Putting the value of displacement = 2m

$$\Rightarrow \quad s = t^4 - t^2$$

$$\Rightarrow \quad t^4 - t^2 - 2 = 0$$

$$\Rightarrow \quad t^2 (t^2 - 2) + (t^2 - 2) = 0$$

$$\Rightarrow \quad (t^2 + 1)\ (t^2 - 2) = 0$$

On solving above equation, we find the value of 't' and is given by.

$$t = \sqrt{2}\ sec$$

Now for acceleration we have,

$$a_t = \frac{dv_t}{dt} = 12t^2 - 2$$

Substituting the value of 't' we get

$$a_t = (12 \times 2) - 2 = 22\ m/s^2$$

$\therefore$ Body's acceleration is $22\ m/s^2$ when it is 2m away from origin.

504. The only force acting on a 2.0 kg body as it moves along a positive x-axis has an x-component $F_x = -6x$ with x in meters. The velocity at x = 3.0 m is 8.0 m/s. The velocity of the body at x = 4.0 m is

(a) 6.6 m/s (b) 46.6 m/s

(c) 60 m/s (d) 96.6 m/s

AMU-2015

Ans. (a) : Given,

m = 2kg

$$W = \int_{x_i}^{x_f} Fx\, dx = \int_{x_1}^{x_f} -6x\, dx$$

$$= -6\left[\frac{x^2}{2}\right]_{x_i}^{x_f} = 3\left[x_f^2 - x_i^2\right]$$

$$= -3\left[4^2 - 3^2\right] = -21J$$

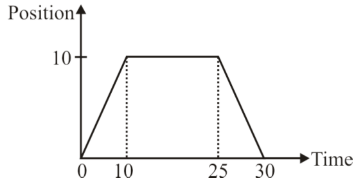
According to work-kinetic energy theorem

$$W = \frac{1}{2}\ m\ \left(V_f^2 - V_i^2\right)$$

$$V_f^2 = \sqrt{\frac{2W}{m} + V_i^2} = \sqrt{\frac{2 \times (21)}{2} + (8)^2}$$

$V_f = 7.62$ ~6.6m/sec

505. Figure shows the position-time graph of an object. Find the ratio of the velocities at 5th and 27th seconds.



(a) $\frac{1}{2}$ (b) $-\frac{1}{2}$

(c) 1 (d) –1

AMU-2014

Ans. (b) : According to graph object is moving with constant velocity for first 10 sec.

So,

Slope of the graph for $0 \le t \le 10$ sec

$$v = \frac{10 - 0}{10 - 0}$$

$$v = \frac{10}{10} = 1\ \ m/s$$

Velocity at 5th second = 1 m/s

Again from graph velocity of the object is constant for last 5 sec.

So, slope of the graph for 25 sec $0 \le t \le 30$ sec

$$v = \frac{0 - 10}{30 - 25}$$

$$v = \frac{-10}{5} = -2\ m/s$$

$\therefore$ Velocity at 27th second = – 2 m/s

$$\therefore \quad \frac{\text{velocity at } 5^{th} \text{ second}}{\text{velocity at } 27^{th} \text{ second}} = -\frac{1}{2}$$

506. The distance traveled 'S' by an accelerated particle of mass m is given by the following relation (in MKS)

$$\mathbf{S = 6t + 3t^2}$$

The velocity of the particle after 2 seconds in

(a) 6 (b) 12

(c) 18 (d) 24

AMU-2012

@apna_pdf

Ans. (c) : Given data,

Distance travelled by particle

$$S = 6t + 3t^2$$

$$\frac{dS}{dt} = 6 + 6t$$

$$t = 2 \text{ sec}$$

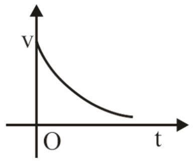
Then,

$$\frac{dS}{dt} = v = 6 + 6 \times 2$$

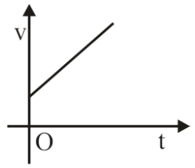
$$v = 18 \text{ m/sec}$$

507. Given below are four curves describing variation of velocity with time of a particle. Which one of these describes the motion of a particle initially in positive direction with constant negative acceleration?

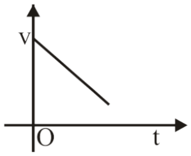
(a) (W)



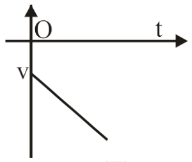
(W)



(X)



(Y)

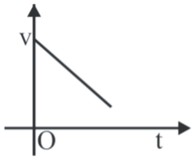


(Z)

(a) (W)
(b) (X)
(c) (Y)
(d) (Z)

AMU-2012

Ans. (c) : When an object is moving with constant negative acceleration, having positive initial velocity, then velocity time graph is a straight line shown below.



508. A boat goes across a river with a velocity 12 km/h. The magnitude of it resultant speed in flowing water is 13 km/h. The velocity of water flow in the river is

(a) 5 km/h
(b) 7 km/h
(c) 9 km/h
(d) 1 km/h

AMU-2012

Ans. (a) : Given data,

Velocity of boat (V_b) = 12 km/h

Resultant speed (V_R) = 13 km/h

Velocity of river water (V_W) = ?

We know that,

$$V_R^2 = V_b^2 + V_W^2$$

$$V_W^2 = V_R^2 - V_b^2$$

$$V_W = \sqrt{V_R^2 - V_b^2} \Rightarrow \sqrt{(13)^2 - (12)^2} = 5 \text{km/h}$$

509. Which one of the following remains constant while throwing a ball upward?

(a) Displacement
(b) Kinetic energy
(c) Acceleration
(d) Velocity

NDA (II) 2008

Ans. (c) : Whenever we throw a ball in upward direction, the gravitational pull acts on the ball which is in downward direction ;Hence, it falls back to the ground under the action of Earth's gravity. Ball falling down under the influence of gravity. Fall with a constant acceleration.

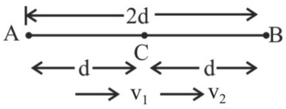
510. If a body travels half the distance with velocity v_1 and next half with velocity v_2, then which one of the following will be the average velocity of the body?

(a) $\sqrt{v_1 v_2}$
(b) $\frac{2v_1 + v_2}{2}$
(c) $\frac{v_2}{v_1}$
(d) $\frac{2v_1 v_2}{v_1 + v_2}$

NDA (II) 2008

Ans. (d): Given,

If a body travels half the distance with velocity v_1 and next half velocity v_2.



Total distance = 2d

Body travels d distance from A to C in t_1 time with velocity v_1 =

$\therefore t_1 = d/v_1$

Similarly,

$t_2 = d/v_2$

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{2d}{\frac{d}{v_1} + \frac{d}{v_2}} = \frac{2dv_1v_2}{d(v_1 + v_2)}$$

$$\text{Average velocity} = \frac{2v_1v_2}{v_1 + v_2}$$

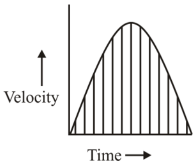
511. Which one of the following characteristics of the particle does the shaded area of the velocity-time graph shown above represent?

(a) momentum
(b) acceleration
(c) distance covered
(d) speed

NDA (II) 2010

@apna_pdf

Ans. (c):



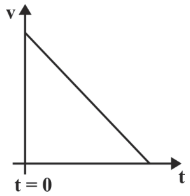
We know that,

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

Distance = velocity ×Time

So, shaded area represented the distance covered by the particle.

512.

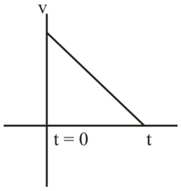


Which one among the following situations is best represented by the velocity - time plot shown above?

(a) Uniform motion of a particle on a circle
(b) Accelerated motion of a particle which has a non-zero initial velocity
(c) Decelerated motion of a particle which has an initial non-zero velocity
(d) Decelerated motion of a particle which has no initial velocity

NDA (II) 2013

Ans. (c) :



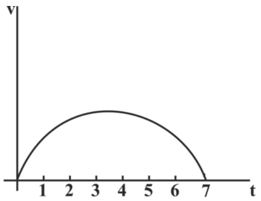
$$a = \frac{dv}{dt}$$

When t = 0

Non zero velocity

Acceleration is decreasing t↑es and v↓es

513.



The plot given above represents the velocity of a particle (in m/s) with time (in seconds). Assuming that the plot represents a semi-circle, distance traversed by the particle at the end of 7 seconds is approximately.

(a) 19 m
(b) 7 m
(c) 3.2 m
(d) 4.75 m

NDA (II) 2013

Ans. (a) : Distance travelled = Area under v-t curve,

∴ Distance travelled in 7sec = Area of semicircle

$$= \frac{1}{2} \times \frac{\pi}{4} \times (7)^2 = \frac{22}{7} \times \frac{1}{8} \times 7 \times 7$$

$$\boxed{s = 19.2 \approx 19\text{m}}$$

514. A particle is moving with uniform acceleration along a straight line *ABC*, where *AB* = *BC*. The average velocity of the particle from A to B is 10 m/s and from B to C is 15 m/s. The average velocity for the whole journey from A to C in m/s is

(a) 12
(b) 12.5
(c) 13
(d) 13.5

NDA (II) 2014

Ans. (a) : ∵ AB = BC

Let AB = BC = d

∴ For AB,

$$v_{AB} = \frac{d}{t_{AB}} \Rightarrow t_{AB} = \frac{d}{10}$$

For BC,

$$v_{BC} = \frac{d}{t_{BC}} \Rightarrow t_{BC} = \frac{d}{10}$$

$$\therefore \quad v_{avg} = \frac{\text{Total distance}}{\text{Total Time}}$$

$$v_{avg} = \frac{2d}{\frac{d}{10} + \frac{d}{15}} = \frac{2}{\frac{1}{10} + \frac{1}{15}} = 12\text{m}$$

515. Two cars *A* and *B* have masses m_A and m_B respectively, with $m_A > m_B$. Both the cars are moving in the same direction with equal kinetic energy. If equal braking force is applied on both, then before coming to rest

(a) *A* will cover a greater distance
(b) *B* will cover a greater distance
(c) both will cover the same distance
(d) distance covered by them will depend on their respective velocities

NDA (II) 2014

Ans. (b) : Given that,

$$K.E_A = K.E_B$$

$$\therefore \quad \frac{1}{2} \frac{P_A^2}{m_A} = \frac{1}{2} \frac{P_B^2}{m_B}$$

$$\because m_A > m_B$$

$$\therefore P_A < P_B$$

@apna_pdf

Now, $F_{ext} = \dfrac{\Delta P}{\Delta t}$

$\Delta P = F_{ext}\,\Delta t$

$F_{ext}\,\Delta t_A < F_{ext}\,\Delta t_B$

$\because$ F_{ext} is same in both case

$\Delta t_A < \Delta t_B$

$\therefore$ Time taken by B is more than A

$\therefore$ Car B will cover a greater distance.

516. If the motion of an object is represented by a straight line parallel to the time axis in a distance-time graph, then the object undergoes

(a) an accelerated motion
(b) a decelerated motion
(c) a uniform non-zero velocity motion
(d) a zero velocity motion

NDA (II) 2014

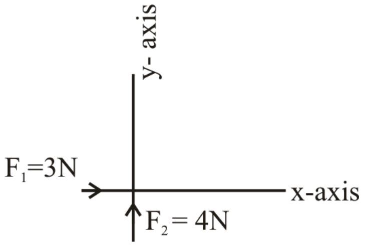
Ans. (d) : As we now that,

$$v = \frac{ds}{dt}$$

Given that, $\dfrac{ds}{dt} = 0$

$v = 0$

517. Two forces, one of 3 newton and another of 4 newton are applied on a standard 1 kg body, placed on a horizontal and friction less surface, simultaneously along the x-axis and the y-axis, respectively, as shown below:



The magnitude of the resultant acceleration is:

(a) 7 m/s^2 (b) 1 m/s^2
(c) 5 m/s^2 (d) $\sqrt{7}$ m/s^2

NDA (II) 2015

Ans. (c) : $F_R = \sqrt{F_1^2 + F_2^2}$

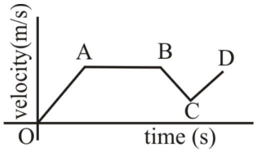
$$F_R = \sqrt{3^2 + 4^2}$$

$$F_R = 5N$$

$\therefore$ $F_R = ma$

$\boxed{a = 5m/s^2}$

518. The following figure represents the velocity-time graph of a moving car on a road:



Which segment of the graph represents the retardation?

(a) AB (b) BC
(c) CD (d) None

NDA (II) 2015

Ans. (b) : As we know that,

$$a = \frac{dv}{dt}$$

In segment BC, $\dfrac{dv}{dt}$ is negative

$\therefore$ Acceleration is negative i.e. retardation motion.

519. A brass ball is tied to a thin wire and swung so as to move uniformly in a horizontal circle. Which of the following statements in this regard is/are true?

1. The ball moves with constant velocity
2. The ball moves with constant speed
3. The ball moves with constant acceleration
4. The magnitude of the acceleration of the ball is constant

Select the correct answer using the code given below:

(a) 1 only
(b) 1 and 3
(c) 1, 2 and 4
(d) 2 and 4 only

NDA (II) 2015

Ans. (d): Since the direction of the movement changes in such motion it can't have constant velocity but velocity magnitude does not change, so speed remains same.
Hence a change but magnitude is same.

520. A racing car accelerates on a straight road from rest to a speed of 50 m/s in 25s. Assuming uniform acceleration of the car throughout, the distance covered in this time will be

(a) 625 m (b) 1250 m
(c) 2500 m (d) 50 m

NDA (I) 2016

Ans. (a) : Given that,

Initial velocity (u) = 0
Final velocity (v) = 50 m/sec
t = 25 second
$v = u + at$
$50 = 0 + a\times 25$
$a = 2 m/sec^2$

Distance covered (s) = $ut + 1/2\, at^2$

$s = 0 \times 25 + 1/2 \times 2 \times (25)^2$
$s = 625$ m

@apna_pdf

(c) Relative Velocity in One Dimension

521. A train of 150 m length is going towards north direction at a speed of 10 ms^{-1}. A parrot flies at speed at $5ms^{-1}$ towards south direction parallel to the railway track. The time taken by the parrot to cross the train is equal to:

(a) 12 s (b) 8 s
(c) 15 s (d) 10 s
(e) 5 s

AP EAMCET (21.09.2020) Shift-I
Manipal UGET-2013
Kerala CEE 2004

Ans. (d) : Given that,

Length of the train = 150m
Speed of the train (v_t) = 10 m/s (North direction)
Speed of parrot (v_P) = 5 m/s (South direction)
We know that,

$$\text{Time} = \frac{\text{Distance}}{\text{Relative Velocity}}$$

$$= \frac{\text{Distance}}{v_t - v_p}$$

$$= \frac{150}{10-(-5)} = \frac{150}{15} = 10 \text{ s}$$

522. A police van moving on a highway with a speed of 30 km h^{-1} fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km h^{-1}. If the muzzle speed of the bullet is 150 m s^{-1}, with what speed does the bullet hit the thief's car?

(a) 90 m s^{-1} (b) 105 m s^{-1}
(c) 110 m s^{-1} (d) 120 m s^{-1}

COMEDK 2017
AMU-2012

Ans. (b) : Given that,

Speed of the police van (v_{police}) = 30km/h $=30\times\frac{5}{18}$
= 8.33m/s
The muzzle speed of the bullet (v_{bullet}) = 150 m/s
Speed of the thief's car (v_{thief}) = 192 km/h
$= 192\times\frac{5}{18}$ =53.33 m/s

The bullet is fired from a moving van, therefore resultant speed can be obtained as:
= 150 + 8.33
= 158.33 m/s

Both the vehicle are moving in the same direction.
So, velocity of the bullet hits the thief's car is,

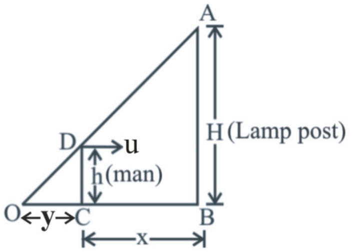
$$v_{relative} = v_{bullet} - v_{thief}$$
$$= 158.33 - 53.33$$
$$= 105 \text{ m/s}$$

523. A man of height h walks in a straight path towards a lamp post of height H with uniform velocity u. Then the velocity of the edge of the shadow on the ground will be:

(a) $\frac{Hu}{(H-h)}$ (b) $\frac{Hu}{(H+h)}$
(c) $\frac{(H-h)}{Hu}$ (d) $\frac{(H+h)}{Hu}$
(e) $\left(\frac{H+h}{H-h}\right)u$

UPSEE 2012
Kerala CEE 2004

Ans. (a): Let, same time the distance covered by man and edge of shadow be respectively x and y.



Where, CD = height of man = h
AB = height of lamp-post = H
y = length of shadow of the man
According to given figure,

$$\Delta ODC \approx \Delta OAB,$$

$$\frac{CD}{BA} = \frac{OC}{OB}$$

$$\frac{h}{H} = \frac{y}{x+y} \Rightarrow \frac{H}{h} = \frac{x+y}{y}$$

$$\frac{H}{h} = \frac{x}{y} + \frac{y}{y} \Rightarrow \frac{H}{h} = \frac{x}{y} + 1$$

$$\frac{x}{y} = \frac{H}{h} - 1$$

$$\frac{H-h}{h} = \frac{x}{y} \quad \text{......(i)}$$

∵ Distance = Speed × time

$$x = ut \quad \text{....(ii)}$$

and $(x+y) = vt$
$ut + y = vt$
$y = (v-u)t \quad \text{.....(iii)}$

From equation (i), (ii) and (iii), we get–

$$\frac{H-h}{h} = \frac{ut}{(v-u)t}$$

$$Hv - Hu - hv + hu = hu$$

$$v(H-h) = Hu$$

$$v = \frac{Hu}{(H-h)}$$

@apna_pdf

524. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72kmh^{-1} in the same direction, with A head of speed B. The driver of B decides to overtake A and accelerates by 1m/s^2. If after 50s, the guard of B just brushes past the driver of A, what was the original distance between them?

(a) 100m (b) 1150m

(c) 1300m (d) 1250m

BCECE-2015
AMU-2012

Ans. (d): Given that,

For train A, $u_A = 72 \text{ km/h} = 72 \times \frac{5}{18} = 20\text{m/s}$

For train B, $u_B = 72 \text{ km/h} = 72 \times \frac{5}{18} = 20\text{m/s}$

$a_B = 1 \text{ m/s}^2, t = 50\text{s}$

Distance covered by train B,

$$s_B = u_B t + \frac{1}{2} a_B t^2$$

$$s_B = 20 \times 50 + \frac{1}{2} \times 1 \times (50)^2$$

$$s_B = 1000 + 1250$$

$$= 2250 \text{ m}$$

Distance covered by train A, $s_A = u_A \times t$

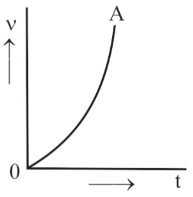
$= 20 \times 50$

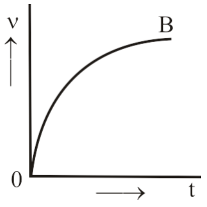
$= 1000\text{m}$

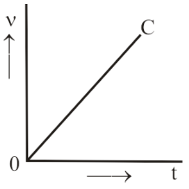
Hence, original distance between train A and B

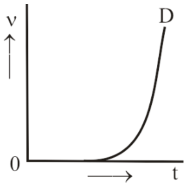
$= s_B - s_A = 2250 - 1000 = 1250\text{m}$

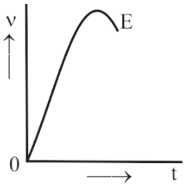
525. Given below are the velocity-time graphs of five particles, A,B,C,D and E. The correct graph from the following v-t plots in which the velocity of the particle is function of t^2 is

(a)


(b)


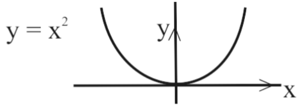
(c)


(d)


(e)


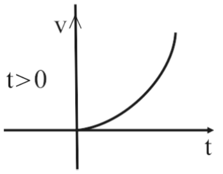
Kerala CEE 04.07.2022

Ans. (a) : The graph of $y = x^2$ is parabolic–



Similarly,

$v(t) = t^2$, for $t>0$



526. The angle made by $\vec{r} = 3\vec{i} + 3\vec{j}$ with the x axis is

(a) 30° (b) 60°

(c) 180° (d) 90°

(e) 45°

Kerala CEE 04.07.2022

Ans. (e) : If $\vec{r} = x\hat{i} + y\hat{j}$ then the angle made by position vector with the x-axis is,

$$\tan\theta_x = \frac{y}{x}$$

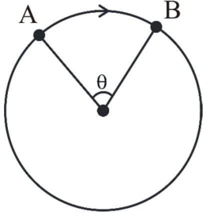
Here, x = 3, y = 3

$$\tan\theta_x = \frac{3}{3} = 1$$

$$\tan\theta_x = \tan 45^\circ$$

$$\theta_x = 45^\circ$$

527. A particle is moving on a circular path with a constant speed v. It's change of velocity as it moves from A to B in the figure is–

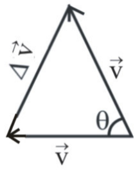


(a) $2v\sin\frac{\theta}{2}$ (b) $v\sin\theta$

(c) $\frac{v\sin 2\theta}{2}$ (d) $2v\sin\theta$

AP EAMCET-07.07.2022, Shift-II

Ans. (a) : According to the question



$$|\Delta\vec{v}| = \sqrt{v^2 + v^2 - 2v^2\cos\theta}$$

$$= \sqrt{2v^2(1-\cos\theta)}$$

$$= \sqrt{4v^2\sin^2\theta/2}$$

$$|\Delta\vec{v}| = 2v\sin\frac{\theta}{2}$$

@apna_pdf

528. Particle A (which is located at the origin at time t=0) is moving along the x- axis with a constant velocity 1 ms^{-1}. Another particle B is moving along the y-axis according to, y=ct^3; c=1 ms^{-1}. Then the velocity of A relative to B at t=1 is

(a) $\sqrt{10}\text{ms}^{-1}$ (b) 10ms^{-1}
(c) $\sqrt{3}\text{ms}^{-1}$ (d) 3ms^{-1}

AP EAMCET-11.07.2022, Shift-II

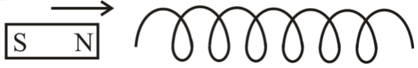
Ans. (a) : Given,

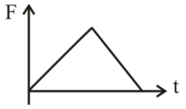
$$v_x = 1 \text{ m/sec}$$
$$y = ct^3$$
$$\frac{dy}{dt} = v = 3ct^2 \text{ [Differentiating w.r.t time]}$$
$$c = 1$$
$$t = 1$$
$$v_y = 3\times1\times1^2$$
$$v_y = 3\text{m/sec}$$

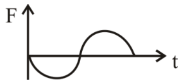
Hence, the velocity of A relative to B

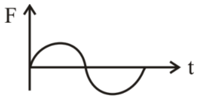
$$\Delta v = \sqrt{v_x^2 + v_y^2}$$
$$= \sqrt{1^2 + 3^2}$$
$$\Delta v = \sqrt{10} \text{ m/sec}$$

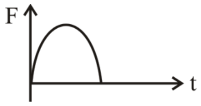
529. The variation of induced emf (F) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as



(a)


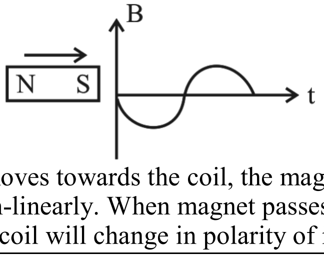
(b)


(c)


(d)


CG PET-2021

Ans. (b) :



As magnet moves towards the coil, the magnetic flux increases non-linearly. When magnet passes on the other side of coil will change in polarity of induced emf.

530. Two cars A and B initially at rest are moving in same direction with accelerations a$_1$ and a$_2$ respectively. After a certain time, they achieve velocities v$_1$ and v$_2$ respectively and separated are by a distance of 50 m. If (a$_1$ – a$_2$) = 4 m/s^2, then the quantity (v$_1$ – v$_2$) will be

(a) 24 m/s (b) 20 m/s
(c) 40 m/s (d) 12 m/s

TS EAMCET 05.08.2021, Shift-I

Ans. (b) : Two car A and B initially at rest are moving in same direction with acceleration a$_1$ and a$_2$ After a certain time, their velocities v$_1$ and v$_2$ respectively and separated by distance (s) = 50 m.

Given, $(a_1 - a_2) = 4 \text{ m/s}^2$ .....(i)

Find, $v_1 - v_2 = ?$

By eq., $s = ut + \frac{1}{2}at^2$

u = {initially at rest}= 0

$$s_1 = \frac{1}{2}a_1t^2$$
$$s_2 = \frac{1}{2}a_2t^2$$
$$\because \quad s_1 - s_2 = \frac{1}{2}t^2(a_1 - a_2) \qquad \because s_1 - s_2 = 50$$
$$50 = \frac{1}{2}t^2(a_1 - a_2) \Rightarrow 100 = t^2(4)$$
$$t^2 = 25$$
$$t = 5$$

and $V_1 = u + a_1t = a_1t$

$$V_2 = u + a_2t = a_2t$$
$$V_1 - V_2 = (a_1 - a_2)t$$
$$= 4\times5$$
$$V_1 - V_2 = 20 \text{ m/s}$$

531. An engine of a train moving with uniform acceleration, passes the signal-post with velocity u and the last compartment with velocity v. The velocity with which middle point of the train passes the signal post is

(a) $\sqrt{\frac{v^2 + u^2}{2}}$ (b) $\frac{v - u}{2}$
(c) $\frac{u + v}{2}$ (d) $\sqrt{\frac{v^2 - u^2}{2}}$

JEE Main-25.02.2021, Shift-I

Ans. (a) : Suppose train length x

So, $v^2 - u^2 = 2ax$

$$x = \frac{v^2 - u^2}{2a} \qquad \text{......(i)}$$

Let the speed of the middle point v$_m$, and s = x/2

$$v_m^2 - u^2 = 2a\left(\frac{x}{2}\right)$$
$$v_m^2 - u^2 = ax \qquad \text{......(ii)}$$

Putting the value of x in equation (ii)

$$v_m^2 - u^2 = a \times \frac{v^2 - u^2}{2a}$$
$$v_m = \sqrt{\frac{v^2 + u^2}{2}}$$

532. Two cars A and B are moving with a velocity of 30 kmph in the same direction. They are separated by 10 km. The speed of another car C moving in the opposite direction, if it meets these two cars at an interval of eight minutes is–

(a) 45 kmph (b) 40 kmph
(c) 15 kmph (d) 30 kmph

AP EAMCET-20.08.2021, Shift-I

@apna_pdf

Ans. (a) : Given data :

$v_A = 30$ km/hr, u = speed of another car

$v_B = 30$ km/hr

L = 10 km

t = 8 minute

So velocity of C with respect to B would be (u+30) opposite direction

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$u + 30 = \frac{10}{\frac{8}{60}}$$

$$u + 30 = \frac{600}{8} = 75$$

u = 70–30 = 45 km/hr

533. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km/h from A to B notices that a bus travelling in the direction of his motion goes past him every 18 minutes and every 6 minutes he notices a bus travelling in the opposite direction go past him. Assuming that the busses travel with a constant speed, find T and the constant speed of the buses.

(a) $\frac{2}{27}$hr and 38 kmph (b) $\frac{5}{8}$hr and 40 kmph

(c) $\frac{3}{20}$hr and 40 kmph (d) $\frac{2}{3}$hr and 28 kmph

AP EAMCET-25.08.2021, Shift-I

Ans. (c) : Let the velocity of the bus be v_B km/h and the period of the bus be t minute.

The speed of the bus travelling in the same direction as the cyclist relative to the cyclist is $(v_B - 20)$ km/h

The speed of the bus travelling the opposite direction as the cyclist relative to the cyclist is $(v_B + 20)$ km/h.

The distance between two consecutive buses travelling in the same direction is d.

$$d = \frac{v_B.t}{60}$$

This distance d is in turn equal to the distance between the cyclist and the next bus at an instant when one bus goes past him.

$$\frac{v_B.t}{60} = \frac{(v_B - 20) \times 18}{60} \text{ -------(i)}$$

$$\frac{v_B.t}{60} = \frac{(v_B + 20) \times 6}{60} \text{ ----------(ii)}$$

From the above equations (i) and (ii) solving, we get

$v_B = 40$ km and t = 9 min or $\frac{3}{20}$ hour

534. If a 100 m long train needs 7.2 seconds to cross an object moving in a direction opposite to the train's direction with a speed of 5 *kmph*, then find the velocity of the train______.

(a) 40 kmph (b) 25 kmph

(c) 45 kmph (d) 20 kmph

AP EAMCET-23.08.2021, Shift-II

Ans. (c) : Given data,

train length = 100 m

time = 7.2 sec

Relative velocity = ?

When the train or two objects are moving in opposite direction at u km/hr and v km/hr then

Relative velocity = u + v

Relative speed = $(u + 5) \times \frac{5}{18}$ m/s

Distance = velocity × time

$$100 = (u + 5) \times \frac{5}{18} \times t$$

$$1800 = (5u + 25) \times 7.2$$

$$1800 = 36u + 180$$

$$36u = 1800 - 180$$

$$u = \frac{1620}{36} = 45\text{km/hr}$$

535. Light from a source travels out with a velocity c. If the source moves away from the observer with a velocity v, then the relative velocity of light with respect to observer is

(a) c (b) c + v

(c) c - v (d) $\sqrt{c^2 + v^2}$

AP EAMCET (17.09.2020) Shift-II

Ans. (a) : The speed of light is the same for any inertial reference, $c = 3 \times 10^8$ m/s

So, it doesn't matter that how fast the source moves away from the observer.

Thus, the relative velocity of light with respect to observer is

$$v = c$$

536. A car travelling at 15 m/s overtake another car travelling at 10 m/s. Assuming, each car is 4m long. What is the time taken during the overtake?

(a) 1.6 s (b) 0.8 s

(c) 0.6 s (d) 0.4 s

TS-EAMCET-10.09.2020, Shift-1

Ans. (a) : Given that,

Velocity of Car A $(v_A) = 15$ m/s, Length of car = 4m

Velocity of Car B $(v_B) = 10$ m/s

The motion of two car A and B is shown in the figure,

4m
15 m/s
A
4m
10 m/s
B

Relative velocity of car A w.r.t. car B is

$v_{AB} = v_A - v_B = 15 - 10 = 5$m/s

Distance to be covered for overtake is –

s = 4m + 4m = 8m

$$\text{Time taken by cars to cross} = \frac{\text{Distance}}{\text{Relative speed}}$$

$$= \frac{s}{v_{AB}} = \frac{8}{5} = 1.6\text{s}$$

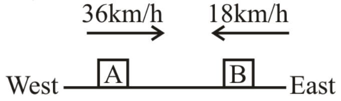
537. Two buses A and B are moving in opposite direction. Now if the first bus A moves towards east with a speed of 36 km/h and bus B moves towards west with a speed of 18 km/h, then the bus B appears to bus A as

@apna_pdf

(a) moving with a speed of 5 m/s from east to west
(b) moving with a speed of 15 m/s from west to east
(c) moving with a speed of 15 m/s from east to west
(d) moving with a speed of 10 m/s from east to west

TS-EAMCET-09.09.2020, Shift-2

Ans. (c) : The given situation is as shown in figure



Velocity of bus A (v_A) = 36 km/h = $36\times\frac{5}{18}=10\text{m}/\text{s}$

Velocity of bus B (v_B) = 18 km/h $=18\times\frac{5}{18}=5\text{ m}/\text{s}$

Let the speed along East is positive,
The relative speed of bus B w.r.t. A is

$$v_{BA} = v_B - v_A = (-5) - (10) = -15 \text{ m/s}$$

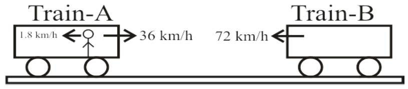
Therefore, the bus B appears to bus A as coming with a speed of 15 m/s from East to West.

538. Trains A and B are running on parallel tracks in the opposite directions with speeds of 36 km/h and 72 km/h, respectively. A person is walking in train A in the opposite direction to its motion with a speed of 1.8 km/h. Speed (in ms^{-1}) of this person as observed from train B will be close to (Take, the distance between the tracks as negligible)

(a) 28.5 (b) 30.5
(c) 29.5 (d) 31.5

JEE Main-02.09.2020, Shift-I

Ans. (c) :



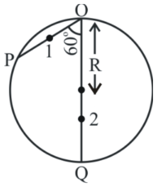
V_A= 36 km/h, V_B = 72 km/h, V_P= 1.8 km/h
Relative speed of train A with respect to person walking in train A.

$$v_{AP} = v_A - v_P$$
$$= 36-1.8 = 34.2 \text{ km/h}$$
$$v = 34.2\times\frac{5}{18} = 9.5 \text{ m/s}$$

Speed of person (walking in train A) as observed from train B

$$u = v_{AP} + v_B$$
$$u = 9.5 + (72\times\frac{5}{18})$$
$$u = 9.5 + 20 \Rightarrow u = 29.5 \text{ m/s}$$

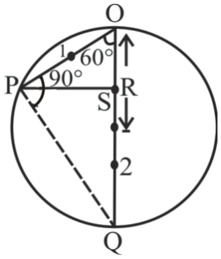
539. Two particles 1 and 2 are allowed to descend on two frictionless chords OP and OQ as shown in the figure. The ratio of the speeds of the particles 1 and 2, respectively when they reach the circumference is



(a) $\frac{1}{2}$ (b) 2
(c) $\frac{3}{2}$ (d) $\frac{2}{3}$

AP EAMCET (22.04.2019) Shift-II

Ans. (a) : Given,



Triangle made in a semicircle is right angle triangle.
In ΔOPQ,

$$\text{Cos } 60° = \frac{OP}{OQ} \Rightarrow OP = OQ\cos 60^\circ$$
$$\Rightarrow OP = 2R\times\frac{1}{2} \Rightarrow OP = R$$

In ΔOPS,

$$\text{Cos } 60° = \frac{OS}{OP}$$
$$OS = OP\cos 60^\circ = R\left(\frac{1}{2}\right)$$
$$OS = \frac{R}{2}$$

Velocity of the particle 1, $v_1=\sqrt{2g(OS)} = \sqrt{gR}$

Velocity of particle 2, $v_2 = \sqrt{2g(OQ)} = 2\sqrt{gR}$

Hence, $\frac{v_1}{v_2}=\frac{\sqrt{gR}}{2\sqrt{gR}}=\frac{1}{2}$

540. A passenger train of length 60m travels at a speed of 80 km/hr. Another freight train of length 120m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when : (i) they are moving in the same direction and (ii) in the opposite direction is

(a) $\frac{3}{2}$ (b) $\frac{25}{11}$
(c) $\frac{11}{5}$ (d) $\frac{5}{2}$

JEE Main-12.01.2019, Shift-I

Ans. (c) : Given data: $l_1 = 60\text{m}$, $v_1 = 80\text{km}/\text{hr}$
$l_2 = 120$ m, $v_2 = 30\text{km}/\text{hr}$

When trains are moving in same direction then relative speed

$$v = 80-30 = 50 \text{ km/h}$$
$$l = 60 \text{ m} + 120 \text{ m} = 180 \text{ m}$$

Total distance (l) = l_1+l_2

$$t_1 = \frac{180}{50}$$

@apna_pdf

When train moving opposite direction relative speed

Speed (v) = 80+30

= 110 km/h

l = 60+120 = 180 m

Time $(t_2) = \frac{180}{110}$

Ratio of t_1 and t_2

$$\frac{t_1}{t_2} = \frac{\frac{180}{50}}{\frac{180}{110}}$$

Or $= 11/5$

541. Two trains A and B travel in two parallel rail tracks in opposite direction with speed v_1 and v_2, respectively. They take 4 s to pass each other at this speed. If the speed of train A is increased by 50%, then they take 3 s to pass each other.

The ratio of v_1/v_2 is

(a) 0 : 5
(b) 1 : 5
(c) 2 : 1
(d) 2 : 5

TS-EAMCET-07.05.2018, Shift-1

Ans. (c): Let distance between them is s.

Relative velocity of trains = v_1+v_2

(i) First they take 4s to cross

$s = (v_1 + v_2)\,4$ …….(i)

(ii) Second they take 3s to cross, when speed of train A is increased by 50%.

Now, relative velocity $= \left(v_1 + \frac{50}{100}v_1\right) + v_2$

$= \left(\frac{3}{2}v_1 + v_2\right)$

∴ $s = \left(\frac{3}{2}v_1 + v_2\right)3$ ………..(ii)

From equation (i) and (ii), we get

$(v_1 + v_2)\,4 = \left(\frac{3}{2}v_1 + v_2\right)3$

$4v_1 + 4v_2 = \frac{9}{2}v_1 + 3v_2$

$v_2 = \frac{v_1}{2}$

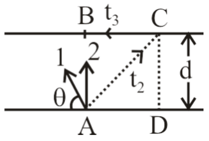
$\frac{v_1}{v_2} = \frac{2}{1}$

542. Two boys both swing at 2.5 km/h across a river with the water velocity of 2km/h. First boy starting from point A on one side of the river crosses the river along a straight line path reaching point B on the other side of the river. AB being perpendicular to the stream. The other boy starts from the same point A and swims right angles to the stream and reaches point C on the other side of the river and walks back to the point B with a velocity u. If both boys reach point B at the same time the value of u is

(a) 2 km/h
(b) 1 km/h
(c) 4 km/h
(d) 3 km/h

TS EAMCET 03.05.2018, Shift-I

Ans. (d): According to the questions



Time taken to cross the river by the swimmer first,

$\vec{v}_{1/R} = 2.5\cos\theta\left(-\hat{i}\right) + 2.5\sin\theta\left(\hat{j}\right)$

⇒ $\vec{v}_1 - \vec{v}_R = -2.5\cos\theta\,\hat{i} + 2.5\sin\theta\,\hat{j}$

⇒ $\vec{v}_1 = \left(2 - 2.5\cos\theta\right)\hat{i} + 2.5\sin\theta\,\hat{j}$

$\left(2 - 2.5\cos\theta = 0,\ \cos\theta = \frac{4}{5} \text{ and } \sin\theta = \frac{3}{5}\right)$

⇒ $\vec{v_1} = 1.5\,\text{km/h}$

∴ $t_1 = \frac{d}{1.5}$

Swimmer second ,

$\vec{v}_{2/R} = 2.5\hat{j}\,\text{km/h}$

⇒ $\vec{v}_2 - \vec{v}_R = 2.5\hat{j}\,\text{km/h}$

⇒ $\vec{v}_2 = \left(2\hat{i} + 2.5\hat{j}\right)\text{km/h}$

∴ $t_2 = \frac{d}{2.5}$

Now, AD = $2t_2 = \frac{2d}{2.5} = ut_3$

$t_3 = \frac{2d}{2.5u}$

Given, $t_1 = t_2 + t_3$

⇒ $\frac{d}{1.5} = \frac{d}{2.5} + \frac{2d}{2.5u}$

⇒ $\frac{2}{25u} = \frac{1}{15} - \frac{1}{25} \Rightarrow \frac{2}{25u} = \frac{2}{75}$

∴ u = 3 km/h

543. In a car race, two cars start with velocities u_1 and u_2 and travel along a straight line with accelerations α and β respectively. If both reach the finish line at the same time then range of the race is

(a) $\frac{2(u_1 - u_2)}{(\beta-\alpha)^2}(u_1\beta - u_2\alpha)$

(b) $\frac{(u_1 - u_2)}{(\beta-\alpha)^2}(u_1\beta - u_2\alpha)$

(c) $\frac{2(u_1 - u_2)}{(\beta-\alpha)^2}(u_1\alpha - u_2\beta)$

(d) $\frac{2(u_1 - u_2)}{(\beta-\alpha)^2}(u_1\beta - u_2\alpha)$

AP EAMCET-25.04.2018, Shift-I

@apna_pdf

Ans. (a) : Given, two cars velocities are u_1 and u_2
Acceleration of both car = α and β
According to question,
For 1st car,

$$s = u_1 t + \frac{\alpha t^2}{2} \qquad \text{........(i)}$$

$$s = u_2 t + \frac{\beta t^2}{2} \qquad \text{........(ii)}$$

From equation (i) and (ii)

$$u_1 t + \frac{\alpha t^2}{2} = u_2 t + \frac{\beta t^2}{2}$$

$$t = \frac{2(u_1 - u_2)}{\beta - \alpha}$$

Put the value of 't' in equation (i)

$$s = \frac{2(u_1 - u_2)(u_1\beta - u_2\alpha)}{(\beta - \alpha)^2}$$

544. A tangent galvanometer has a reduction factor of 1 A and it is placed with the plane of its coil perpendicular to the magnetic meridian. The deflection produced when a current of 1 A is passed through it is:

(a) 60^0 (b) 45^0
(c) 30^0 (d) None of these

Karnataka CET-2005

Ans. (b) : Given, Current (I) = 1A
Reduction factor (K) = 1A

$$\because \quad \tan\theta = \frac{I}{K}$$

$$\therefore \quad \tan\theta = \frac{1}{1}$$

$$\tan\theta = \tan 45^0$$

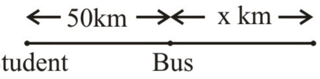
$$\theta = 45^o$$

545. A student is standing at a distance of 50 metres from the bus. As soon as the bus begins its motion with an acceleration of 1 m/s^2, the student starts running towards the bus with a uniform velocity u. Assuming the motion to be along a straight road, the minimum value of u. So that the student is able to catch the bus is :

(a) 8 ms^{-1} (b) 5 ms^{-1}
(c) 12 ms^{-1} (d) 10 ms^{-1}

Karnataka CET-2003

Ans. (d) :



we know that student velocity is uniform then,

$$s_1 = ut \quad \text{.....(i)}$$

Distance travelled by bus in same time t

$$S_2 = ut + \frac{1}{2}at^2$$

$$x = 0 + \frac{1}{2}at^2$$

$$x = \frac{1}{2}t^2 \text{ .... (ii)}$$

total travell distance by student

$$s_1 = x + 50$$

$$ut = \frac{1}{2} + 2 + 50$$

$$t^2 - 2ut + 100 = 0$$

$\because$ For real value of t

$$(2u)^2 - 4 \times 100 \geq 0$$

$$u^2 - 100 \geq 0$$

$$u \geq 10$$

$$u_{min} = 10 \text{ m/s}$$

546. From a balloon rising vertically upwards at 5 m/s a stone is thrown up at 10 m/s relative to the balloon. Its velocity with respect to ground after 2 s is (assume g = 10 m/s^2)

(a) 0 (b) 20 m/s
(c) 10 m/s (d) 5 m/s

J&K CET- 2006

Ans. (d): Initial velocity of stone (u) = 10 m/s + 5 m/s
= 15 m/s

After 2 sec. its velocity, v = u – gt
v = 15 – 10 × 2
v = –5 m/sec

The magnitude of velocity cannot be negative.
So, velocity of stone is 5m/s upward.

547. The velocity of sound in a gas is 1300 m/s at STP and specific heat at constant pressure is 6.84 cal K^{-1} mol^{-1}. The rms velocity at STP is (R = 1.98 cal K^{-1} mol^{-1})

(a) 1300 m/s (b) 2600 m/s
(c) 1898 m/s (d) 650 m/s

J&K-CET-2013

Ans. (c) : Given, $v_s = 1300$ m/s, R = 1.98 cal K^{-1} mol^{-1}
$C_p = 6.84$ cal K^{-1} mol^{-1}

$$\because \quad R = C_p - C_v$$

$$1.98 = 6.84 - C_v$$

$$C_v = 4.86$$

And $$\gamma = \frac{C_p}{C_v} = \frac{6.84}{4.86}$$

$$\gamma = 1.41$$

Now, $$v_{rms} = v_s\sqrt{\frac{3}{\gamma}}$$

$$= 1300\sqrt{\frac{3}{1.41}}$$

$$= 1300\sqrt{2.13} = 1300 \times 1.46$$

$$v_{rms} \approx 1898 \text{ m/s}$$

@apna_pdf

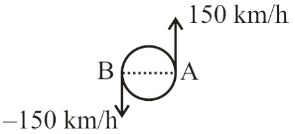
548. An aeroplane is flying with a uniform speed of 150 km h^{-1} along the circumference of a circle. The change in its velocity in half the revolution (in km h^{-1}) is

(a) 150 (b) 100
(c) 200 (d) 300
(e) 50

Kerala CEE - 2016

Ans. (d): Change in velocity = final velocity – initial velocity

$$\Delta v = v_2 - v_1$$



The change in velocity in half revolution

$$\Delta v = 150\hat{j} - (-150\hat{j})$$

$$|\Delta v| = 300\text{km/h}$$

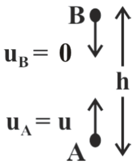
Because the magnitude of both velocities are same but the directions are opposite.

549. A ball A is thrown up vertically with a speed u and at the same instant another B is released from a height h. At time t, the speed of A relative to B is

(a) u (b) 2u
(c) u – gt (d) $\sqrt{(u^2 - gt)}$
(e) gt

Kerala CEE - 2009

Ans. (a): According to question –



From equation of motion

$$v = u + gt$$

Where 'u' is initial velocity and 't' is time

For ball A,

$$v_A = u - gt$$

For ball,

$$v_B = 0 + gt$$

∴ The speed of A relative to B is, $v_{AB} = v_A - v_B$

$$= (u - gt) - (-gt) \text{ (direction of } v_B \text{ is downward)}$$

$$= u$$

550. Two trains are moving with equal speed in opposite directions along two parallel railway tracks. If the wind is blowing with speed u along the track so that the relative velocities of the trains with respect to the wind are in the ratio 1:2, then the speed of each train must be

(a) 3u (b) 2u
(c) 5u (d) 4u
(e) u

Kerala CEE 2007

Ans. (a) : Let, the speed of trains be v.

Relative velocity of the train with respect to wind are v_1 and v_2 respectively.

First train,

$v_1 = v - u$ (opposite direction of the track)

Second train,

$v_2 = v + u$ (Along the track)

$$\frac{v_1}{v_2} = \frac{1}{2} \quad \text{(given)}$$

$$\frac{v - u}{v + u} = \frac{1}{2}$$

$$2v - 2u = v + u$$

$$v = 3u$$

551. A 500 kg boat is 9 m long and is floating without motion on still water. A man of mass 100 kg is at one end and if he runs to the other end of the boat and stops, the displacement of the boat is

(a) 1.5 m in the direction of displacement of the man
(b) 0.75 m in the direction of displacement of the man
(c) 1.5 m in the direction opposite to the displacement of the man
(d) 0.75 m in the direction opposite to the displacement of the man

UPSEE - 2012

Ans. (c) : Let the displacement of boat be x, in opposite direction to the displacement of man.

So, by law of conservation of momentum

$$\text{Mass of man} \times \frac{(9-x)}{t} = \text{mass of boat} \times x/t$$

$$100\,(9-x) = 500x$$

$$9 - x = 5x \Rightarrow 6x = 9$$

$$x = \frac{9}{6} = 1.5\text{m}$$

Hence, displacement of the boat is 1.5m in opposite direction to the displacement of the man.

552. A scooter going to the east at 10 m/s turns right through an angle of 90º. If the speed of the scooter remains unchanged in taking this turn, the change in the velocity of the scooter is

(a) 20 m/s in south-west direction
(b) zero
(c) 10.0 m/s in south direction
(d) 14.14 m/s in south-western direction

UPSEE - 2012

Ans. (d) : Initial velocity $(v_i) = 10\hat{i}$ m/s

Final velocity $(v_f) = -10\hat{j}$ m/s

Change in velocity (Δv) = $v_f - v_i$

$$= -10\hat{j} - 10\hat{i}$$

Magnitude of change in velocity,

$$(\Delta v) = \sqrt{(10)^2 + (10)^2} = 10\sqrt{2}$$

= 14.14 m/s in south-western direction

@apna_pdf

553. Rain is falling vertically downwards with a velocity of 3 km/ hr. A man walks in the rain with a velocity of 4 km/hr. The rain drop will fall on the man with a velocity of

(a) 5 km/hr (b) 4 km/hr

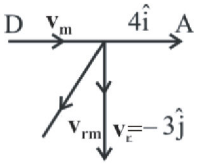
(c) 1 km/hr (d) 3 km/hr

AIIMS-1997

Ans. (a) : Given,

Velocity of Rain $(v_r) = 3$ km/hr

Velocity of man $(v_m) = 4$ km/hr



Relative velocity of rain w.r.t. man :

$$\vec{v}_{rm} = \vec{v}_r - \vec{v}_m$$

$$= -3\hat{j} - 4\hat{i}$$

$$\left|\vec{v}_{rm}\right| = \sqrt{(-3)^2 + (-4)^2}$$

$$= \sqrt{9+16} = \sqrt{25}$$

$$= 5 \text{ km/h}$$

554. A 150 m long train is travelling from east to west at a speed of 20ms^{-1}. A bird is flying from west to east at a speed of 5ms^{-1}. How long will the bird take to cross the train?

(a) 6s (b) 7.5s

(c) 10s (d) 30s

BCECE-2009

Ans. (a): According to question,

Relative velocity of bird with respect to train

$$v_{relative} = v_{bird} - v_{train}$$

$$= 5 - (-20)$$

$$= 25 \text{ m/s}$$

$$\text{Time taken by bird} = \frac{\text{Distance}}{\text{Relative velocity}}$$

$$t = \frac{d}{v_{relative}} = \frac{150}{25}$$

$$t = 6 \text{ sec}$$

555. A train 100m long travelling at 40 m/s starts overtaking another train 200 m long travelling at 30 m/s. The time taken by the first train to pass the second train completely is–

(a) 30 s (b) 40 s

(c) 50 s (d) 60 s

BCECE-2011

Ans. (a) : Given,

Length of first train $(L_1) = 100$ m,

velocity $(v_1) = 40$ m/s

Length of second train $L_2 = 200$ m,

velocity $v_2 = 30$ m/s

Relative velocity of first train with respect to second train $v = v_1 - v_2$

$$v = 40 - 30$$

$$v = 10 \text{ m/s}$$

Total distance to be covered,

$$d = 100 + 200 = 300\text{m}$$

$$\text{Time taken (t)} = \frac{\text{Distance (d)}}{\text{Relative velocity (v)}}$$

$$t = \frac{300}{10}$$

$$t = 30 \text{ sec}$$

556. If a person sitting in a train moving with a constant velocity along a straight line, throws a ball vertically upwards, then :

(a) ball will fall onwards the train

(b) ball will return to thrower's hand

(c) ball will not return to thrower's hand

(d) none of the above

BCECE-2004

Ans. (b): When the ball is thrown in vertically upward direction and given that the train is moving up with a constant velocity. Therefore, the horizontal velocity of the train and ball are both same and the ball travels the same horizontal distance as that of the train. Therefore, the ball will come back into the hands of thrower.

557. A person is at a distance x from a bus when the bus begins to move with a constant acceleration a. What is the minimum velocity with which the person should run towards the bus so as to catch it?

(a) 2ax (b) $\sqrt{2ax}$

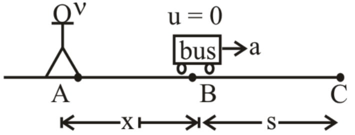
(c) ax (d) $\sqrt{ax}$

BCECE-2010

Ans. (b) : Let the person moving with constant velocity v catches the bus at point in time t.

For bus :

Initial speed of the bus (u) = 0



We know that,

$$s = 0 + \frac{1}{2}at^2 = \frac{1}{2}at^2$$

For person:

$$x + s = vt$$

$$x + \frac{1}{2}at^2 = vt$$

$$at^2 - 2\,vt + 2x = 0$$

For the above equation to have real roots, then

$$b^2 - 4ac \geq 0$$

$$(-2v)^2 - 4a\,(2x) \geq 0$$

$$4v^2 - 8ax \geq 0$$

$$\therefore \quad v^2 \geq 2ax \Rightarrow v \geq \sqrt{2ax}$$

Thus, minimum velocity of the passenger

$$V_{min} = \sqrt{2ax}$$

@apna_pdf

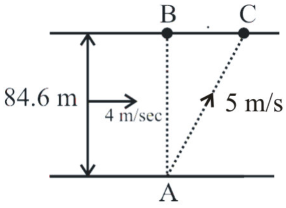
558. A person reaches a point directly opposite on the other band of a river. The velocity of the water in the river is 4 ms^{-1}and the velocity of the person in still water is 5 ms^{-1} .If the width of the river is 84.6 m, time taken to cross the river in seconds is

(a) 28.2 (b) 9.4

(c) 2 (d) 84.6

AP EAMCET(Medical)-2013

Ans. (a): Given that,
Velocity of water in river (v_r) = 4 m/sec
Velocity of person (v_p) = 5 m/sec
Width of river (d) = 84.6 m



$$\text{Time} = \frac{\text{Distance}}{\text{Velocity}}$$

$$t = \frac{d}{\sqrt{v_p^2 - v_r^2}}$$

$$t = \frac{84.6}{\sqrt{v_p^2 - v_r^2}} \Rightarrow t = \frac{84.6}{\sqrt{5^2 - 4^2}}$$

$$t = \frac{84.6}{\sqrt{9}} \Rightarrow t = \frac{84.6}{3}$$

$$t = 28.2 \text{ sec}$$

Time taken to the cross the river in seconds is 28.2 sec.

559. Two cars going round curve with speeds one at 90km/h and other at 15 km/h. Each car experiences same acceleration. The radii of curves are in the ratio of :

(a) 4 : 1 (b) 2 : 1

(c) 16 : 1 (d) 36 : 1

AP EAMCET(Medical)-1998

Ans. (d) : Given, speed of first car (v_1) = 90 km/h
Speed of second car (v_2) = 15 km/h

We know that, circular acceleration (a) = $\frac{v^2}{r}$

According to question, both car have same acceleration
So, $a_1 = a_2$

$$\frac{v_1^2}{r_1} = \frac{v_2^2}{r_2}$$

$$\frac{r_1}{r_2} = \frac{v_1^2}{v_2^2}$$

$$\frac{r_1}{r_2} = \frac{(90)^2}{(15)^2}$$

$$\frac{r_1}{r_2} = \frac{90\times90}{15\times15} = \frac{36}{1}$$

$$r_1 : r_2 = 36:1$$

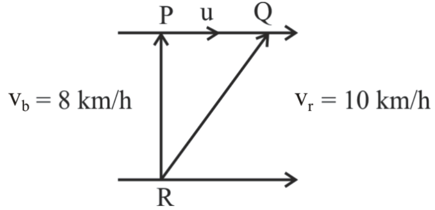
560. A boat is sent across a river with a velocity of 8 kmh^{-1}. If the resultant velocity of boat is 10 km h^{-1}, then velocity of river is

(a) 12.8 km h^{-1} (b) 6 km h^{-1}

(c) 8 km h^{-1} (d) 10 km h^{-1}

[AIPMT 1993]

Ans. (b) : Given,
Velocity of boat (v_b) = 8 km/h
Resultant velocity of boat (v_r) = 10 km/h
Velocity of the river = ?
Let, velocity of river is 'u'



Applying Pythagoras theorem

$$v_r^2 = v_b^2 + u^2$$

$$u^2 = v_r^2 - v_b^2$$

$$u^2 = \sqrt{v_r^2 - v_b^2}$$

Put the value of v_r and v_b

$$u = \sqrt{(10)^2 - (8)^2}$$

$$= \sqrt{36}$$

$$\boxed{u = 6\text{km}/\text{h}}$$

Hence, velocity of the river is 6 km/h

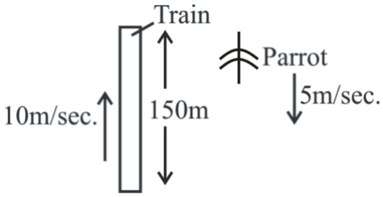
561. A train of 150 m length is going towards North direction at a speed of 10 m/s. A parrot flies at the speed of 5 m/s towards South direction parallel to the railways track. The time taken by the parrot to cross the train is

(a) 12 s (b) 8 s

(c) 15 s (d) 10 s

[AIPMT 1992]

Ans. (d) :



Length of train = distance covered by parrot = 150 m

Relative velocity of the Parrot w.r.t the train
= Parrot speed – train speed
= 5–(–10)

$$\Delta V = +15 \text{m}/\text{sec}$$

Hence time taken by the Parrot to cross the train

$$= \frac{\text{total distance}}{\text{Relative velocity}}$$

$$= \frac{150}{15}$$

t = 10 sec

Hence, the time taken by the parrot to cross the train is 10 sec.

@apna_pdf

562. In any system, large number of particles are moving randomly with a constant speed of ν in all possible directions. Then the magnitude of the relative velocity between a of particles averaged over all the pairs in the collection will be

(a) 0 (b) $2\pi\nu$

(c) $\frac{2\nu}{\pi}$ (d) $\frac{4\nu}{\pi}$

Assam CEE-2014

Ans. (d) :
Relative speed

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

$$|v_{AB}| = \sqrt{v^2 + v^2 - 2v^2\cos\theta}$$

$$= 2v\sin\frac{\theta}{2}$$

$$(v_{AB})_{average} = \frac{\int_0^{2\pi} v_{AB}d\theta}{\int_0^{2\pi} d\theta}$$

$$\frac{1}{2\pi}\int_0^{2\pi} 2v\sin\frac{\theta}{2}d\theta$$

$$= \frac{2v}{\pi}\left|-\cos\left(\frac{\theta}{2}\right)\right|_0^{2\pi}$$

$$(v_{AB})_{Avg} = \frac{4v}{\pi}$$

563. A car accelerates from rest with acceleration 1.2 m/s². A bus moves with constant speed of 12 m/s in a parallel lane. How long does the car take from its start to meet the bus?

(a) 17 s (b) 8 s

(c) 20 s (d) 12 s

NDA (I) 2008

Ans. (c): Given that,

$a = 1.2$ m/s^2

$s = 12$ t m/s

We know that,

$s = ut + 1/2\ at^2$

$12t = 0\times t + 1/2\ 1.2\times t^2$

$12t = 0.6t^2$

$t = 20$ sec

564. A ball of mass 10 kg is moving with a velocity of 10 m/s. It strikes another ball of mass 5 kg, which is moving in the same direction with a velocity of 4 m/s. If the collision is elastic their velocities after collision will be respectively:

(a) 12 m/s, 6 m/s

(b) 12 m/s, 25 m/s

(c) 6 m/s, 12 m/s

(d) 8 m/s, 20 m/s

AIIMS-2000

Ans. (c) : Let the velocities of balls after collision be v_1 m/s and v_2 m/s.

Initial velocity of ball of mass 10 kg (u_1) = 10 m/s

Initial velocity of ball of mass 5kg (u_2) = 4m/s

We know that, in elastic collision -

Relative velocity of approach = Relative velocity of separation

$u_1 - u_2 = v_2 - v_1$

$10 - 4 = v_2 - v_1$

$v_2 - v_1 = 6$ m/s .....(i)

Applying law of conservation of momentum -

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$10 \times 10 + 5 \times 4 = 10 \times (v_2 - 6) + 5 \times v_2$

$120 = 10v_2 - 60 + 5v_2$

$180 = 15v_2$

$v_2 = 12$ m/s

Putting value of v_2 in equation (i)

$v_1 = (v_2 - 6)$ m/s

$= 12 - 6$

$= 6$ m/s

Hence, the velocities after collision are $v_1 = 6$ m/s and $v_2 = 12$ m/s.

565. A man is 45 m behind the bus when the bus start accelerating from rest with acceleration 2.5 m/s². With what minimum velocity should the man start running to catch the bus?

(a) 12 m/s (b) 14 m/s

(c) 15 m/s (d) 16 m/s

J&K CET- 2005

Ans. (c) : Given that,

$a = 2.5$ m/s^2

$s = 45$m

Bus starts from rest, $u = 0$

∴Now, applying third law of motion

$v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 2.5 \times 45$

$v^2 = 5 \times 45 = 225$

$v = \sqrt{225} = 15$ m/s

(d) Equation of Motion

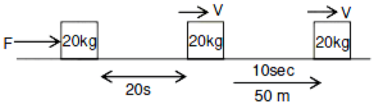
566. A force acts for 20 s on a body of mass 20 kg, starting form rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be:

(a) 40 N (b) 20 N

(c) 5 N (d) 10 N

JEE Main-29.01.2023, Shift-II

Ans. (c) :



Velocity when the body move 50 m in next 10 sec.

$$v = \frac{50}{10} = 5 \text{ m/s}$$

We know that, $v = u + at$ $(\because u = 0)$

@apna_pdf

$$5 = 0 + a \times 20$$
$$a = 1/4 \text{ m/s}^2$$

Force on the body (F) = ma

$$F = 20 \times 1/4 = 5 \text{ N}$$

567. Given below are two statement

Statement I : An elevator can go up or down with uniform speed when its weight is balanced with the tension of its cable.

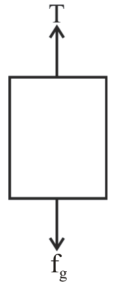
Statement II: Force exerted by the floor of an elevator on the foot a person standing on it is more than his/her weight when the elevator goes down with increasing speed.

In the light of the above statement, choose the correct from the options given below:

(a) Statement I is false but Statement II is true
(b) Statement I is true but Statement II is false
(c) Both Statement I and Statement II are false
(d) Both Statement I and Statement II are true

JEE Main-24.01.2023, Shift-I

Ans. (b) : When the weight of elevator is balance with tension of its cable then it go up or down with uniform speed.



$$W - N = \frac{Wa}{g}$$
$$N = W\left(1 - \frac{a}{g}\right)$$

The force exerted by the elevator on the foot of a person standing is more than the weight of the person when the direction of acceleration of the elevator in the upward direction.

568. For a train engine moving with speed of 20 ms^{-1}, the driver must apply brakes at a distance of 500m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}$ ms^{-1}. The value of x is _____. (Assuming same retardation is produced by brakes)

JEE Main-01.02.2023, Shift-II

Ans. (200) : Given that, Initial velocity of train (u) = 20m/sec, distance (s) = 500m, v = 0 m/s

Condition-I

We know that, $v^2 - u^2 = 2as$

$$0 - (20)^2 = 2 \times a \times 500$$
$$a = -\frac{400}{1000} = -0.4 \text{m/s}^2$$

(–ve sing tells that direction of acceleration is opposite to direction of velocity)

Condition-II

When distance is half (s) = 250m

$$v^2 - u^2 = 2as$$
$$v^2 - (20)^2 = 2 \times (-0.4) \times 250$$
$$v^2 = 400 - 200 = 200$$
$$v = \sqrt{200} \text{m/s}$$
$$x = 200$$

569. Spherical insulating ball and a spherical metallic ball of same size and mass are dropped from the same height. Choose the correct statement out of the following

{Assume negligible air friction}

(a) Both will reach the earth's surface simultaneously.
(b) Insulating ball will reach the earth's surface earlier than the metal ball
(c) Metal ball will reach the earth's surface earlier than the insulating ball
(d) Time taken by them to reach the earth's surface will be independent of the properties of their materials

JEE Main-31.01.2023, Shift-I

Ans. (b) : Magnetic field lines of earth cut in the case of conductor and develop eddy current which oppose the motion of conductor

570. A particle moves along a straight line OX. At a time t (in second), the distance x (in metre) of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest?

(a) 24 m	(b) 40 m
(c) 56 m	(d) 16 m

[AIPMT 2006]
JIPMER - 2008

Ans. (c) : Given, $x = 40 + 12t - t^3$

Velocity $(v) = \frac{dx}{dt} = 0 + 12 - 3t^2$

At coming to rest (v = 0),

$$0 = 12 - 3t^2$$
$$t^2 = 4 \Rightarrow t = 2 \text{ sec}$$

The distance travelled by particle before coming to rest

$$x = 40 + 12(2) - (2)^3$$
$$x = 56 \text{ m}$$

571. The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}$m/s^2, in the third second is.

(a) $^{10}/_3$ m	(b) $^{19}/_3$ m
(c) 6 m	(d) 4 m

CG PET-22.05.2022

@apna_pdf

Ans. (a) : Given,

Acceleration(a) = $\frac{4}{3} m/s^2$

Distance covered in n^{th} second

$$s_n = u + \frac{1}{2} a(2n-1)$$

Distance covered by particle in third second is–

$$s_3 = 0 + \frac{1}{2} \times \frac{4}{3}(2 \times 3 - 1) \quad \text{(initial velocity u = 0)}$$

$$\boxed{s_3 = \frac{10}{3} m}$$

572. A ball under uniform acceleration travels 6m in first 2s and 16m in the next 2s. Its initial velocity is

(a) $\frac{1}{2} m/s$ (b) 1 m/s

(c) $\frac{8}{3} m/s$ (d) $\frac{1}{4} m/s$

TS EAMCET 30.07.2022, Shift-II

Ans. (a) : Given,

Distance travelled $(s_1) = 6$ m

Distance travelled $(s_2) = 16$ m

Time taken by s_1 $(t_1) = 2$ s

Time taken by s_2 $(t_2) = 4$ s

Let the initial velocity be u

We know,

$$s = ut + \frac{1}{2}at^2$$

When $s_1 = 6$ m, $t_1 = 2$ s

$6 = 2u + 2a$ ……(1)

and when $s = s_1 + s_2 = 22m$

$t = t_1 + t_2 = 4$ s

$22 = 4u + 8a$ …..(2)

On solving equation (1) and equation (2), we get

$$u = \frac{1}{2} m/s$$

573. The position of a particle is r = xi + yj where x and y are function of time t and given as x=(12 + 5t – t^2)m and y=(18 + 5t – t^2)m. At t = 1s, the magnitude of the velocity vector of the particle is

(a) $2\sqrt{3} m/s$ (b) $3\sqrt{2} m/s$

(c) $4\sqrt{2} m/s$ (d) $3\sqrt{3} m/s$

TS EAMCET 30.07.2022, Shift-II

Ans. (b) : Given,

Position $(\vec{r}) = xi + yj$

Where, $x = 12 + 5t - t^2$

$y = 18 + 5t - t^2$

We know,

$$\vec{v} = \frac{\vec{dr}}{dt}$$

Differentiating the $\vec{r}$,

$$\frac{dr}{dt} = (5-2t)\hat{i} + (5-2t)\hat{j}$$

$$v_{t=1s} = (5-2t)\hat{i} + (5-2t)\hat{j}$$

$$v_{t=1s} = 3\hat{i} + 3\hat{j}$$

$$|v| = \sqrt{3^2 + 3^2}$$

$$|v| = 3\sqrt{2} m/s$$

574. The velocity-time(v-t) relation of a particle moving in a plane is v = 3t² m/s. At t = 0 ; displacement x = 8 m. The velocity of the particle at x = 16 m is

(a) 12 m/s (b) 14 m/s

(c) 18 m/s (d) 10 m/s

TS EAMCET 31.07.2022, Shift-II

Ans. (a) : Give that, $v = 3t^2$

Differentiation of displacement gives velocity i.e.

$$\frac{dx}{dt} = v$$

$vdt = dx$

Integrating both side, we get

$$\int 3t^2 dt = \int dx$$

$$\frac{3t^3}{3} + c = x$$

$t^3 + c = x$ ……. (i)

At t = 0, x = 8

$(0)^3 + c = 8 \Rightarrow c = 8$

Putting value of c in eq^n (i), we get

$t^3 + 8 = x$

At $x = 16m, t = ?$

$t^3 + 8 = 16 \Rightarrow t = 2$ sec.

Then, $v = 3t^2$

$= 3 \times (2)^2$

$= 12$ m/s

575. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at a height of 19.6 m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is :
[Given g=9.8 m/s²]

(a) 5 m (b) 10 m

(c) 19.8 m (d) 24.5 m

JEE Main-28.07.2022, Shift-I

Ans. (a) : Given, u = 0 m/s, s = 19.6 m

$$v = 9 \text{ km/h} = 9 \times \frac{5}{18} = \frac{5}{2} m/s$$

$$\because \quad s = ut + \frac{1}{2}at^2$$

$$19.6 = 0 + \frac{1}{2}(9.8)t^2$$

$t^2 = 4$

$t = 2$ sec

Now, $d = 2 \times \frac{5}{2} = 5m$

@apna_pdf

576. A ball is spin with angular acceleration $\alpha=6t^2-2t$, where t is in second and α is in rads^{-2}. At t=0, the ball has angular velocity of 10 rads^{-1} and angular position of 4 rad. The most appropriate expression for the angular position of the ball is:

(a) $\frac{3}{4}t^4-t^2+10t$ (b) $\frac{t^4}{2}-\frac{t^3}{3}+10t+4$

(c) $\frac{2t^4}{3}-\frac{t^3}{6}+10t+12$ (d) $2t^4-\frac{t^3}{2}+5t+4$

JEE Main-28.06.2022, Shift-II

Ans. (b) : Given, $\alpha = 6t^2 - 2t$

$\because \quad \alpha = \frac{d\omega}{dt}$

$\therefore \quad d\omega = (6t^2-2t)dt$

Integrating both side,

$$\int_{10}^{\omega} d\omega = \int_0^t (6t^2-2t)\,dt$$

$$\omega - 10 = \left[\frac{6t^3}{3}\right]_0^t - \left[\frac{2t^2}{2}\right]_0^t$$

$$\omega - 10 = 2t^3 - t^2$$

$$\omega = 2t^3 - t^2 + 10$$

$\because \quad \omega = \frac{d\theta}{dt}$

$\therefore \quad d\theta = (2t^3-t^2+10)\,dt$

Now, again integrating both side,

$$\int_4^{\theta} d\theta = \int_0^t (2t^3-t^2+10)\,dt$$

$$\theta - 4 = \frac{2t^4}{4}-\frac{t^3}{3}+10t$$

$$\theta = \frac{t^4}{2}-\frac{t^3}{3}+10t+4$$

577. Two buses P and Q start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = ft - t^2$. At what time, both the buses have same velocity?

(a) $\frac{\alpha-f}{1+\beta}$ (b) $\frac{\alpha+f}{2(\beta-1)}$

(c) $\frac{\alpha+f}{2(1+\beta)}$ (d) $\frac{f-\alpha}{2(1+\beta)}$

JEE Main-25.06.2022, Shift-II

Ans. (d) : $X_P(t) = \alpha t + \beta t^2$--------------(1)

$X_Q(t) = ft - t^2$-------------------(2)

From equation (1) $v_P = \frac{d[X_P(t)]}{dt} = \alpha + 2\beta t$

From equation (2) $v_Q = \frac{d[X_Q(t)]}{dt} = f - 2t$

For $\quad v_P = v_Q$

$$\alpha + 2\beta t = f - 2t$$

$$t(2\beta + 2) = f - \alpha$$

$$t = \frac{f-\alpha}{2\beta+2}$$

$$t = \frac{f-\alpha}{2(\beta+1)}$$

578. A body starts from rest with uniform acceleration and moves in a straight line. If its speed after 'n' seconds is 'v', then the distance covered in the last 2 sec is,

(a) $\frac{2v(n+1)}{n}$ (b) $\frac{v(n+1)}{n}$

(c) $\frac{v(n-1)}{n}$ (d) $\frac{2v(n-1)}{n}$

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (d) : Initial velocity of body (u) = 0

Let the acceleration be a

Using , v = u + a t

$v = 0 + an \qquad (\because\ t = n \text{ given})$

$\Rightarrow a = \frac{v}{n}$

For displacement in n Second,

Using , $s = ut - \frac{at^2}{2}$

$$s = 0 + \frac{v}{2n}(n)^2$$

$$s = \frac{1}{2}\frac{v}{n}(n^2)......(i)$$

for displacement in n–2 sec.

$$s = ut + \frac{1}{2}at^2 \Rightarrow s = 0 + \frac{1}{2}\frac{v}{n}(n-2)^2$$

$$s = \frac{1}{2}\frac{v}{n}(n-2)^2..........(ii)$$

from eqn (i) and (ii)

$$S_2 = S_n - S_{n-2}$$

$$= \frac{1}{2}\frac{v}{n}(n^2 - n^2 + 4n - 4)$$

$$S_2 = \frac{2v}{n}(n-1)$$

579. A car starts from rest and accelerates at 5m/s^2. At = 4s, a ball is dropped out of a window by a person sitting in the car. What is the velocity and acceleration of the ball at t = 6 s? (Take, g =10m/s^2)

(a) 20 m/s, 5 m/s^2 (b) 20 m/s 0

(c) $20\sqrt{2}$ m/s, 0 (d) $20\sqrt{2}$ m/s, 10 m/s^2

[NEET 2021]

Ans. (d) : Given, u = 0, t = 6 sec

a = 5 m/s^2, t = 4 sec

By 1st equation of motion,

$v_x = u + at$

$v_x = 0 + 5 \times 4$

$v_x = 20$ m/s----------------(1)

@apna_pdf

at $t = 6$ sec

$v_y = u + gt$

$v_y = 0 + 10 \times 2$

$v_y = 20$ m/s

$v_{net} = \sqrt{v_x^2 + v_y^2}$

$v_{net} = \sqrt{20^2 + 20^2}$

$v_{net} = 20\sqrt{2}$ m/s

Acceleration (a) = gravity

$a = 10$ m/s^2

580. A stone is dropped from the top of a building. When it crosses a point 5 m below the top, another stone starts to fall from a point 25 m below the top. Both stones reach the bottom of building simultaneously. The height of the building is

(a) 45 m (b) 25 m

(c) 35 m (d) 50 m

JEE Main-25.02.2021, Shift-II

Ans. (a) :

From equation of motion

$v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 10 \times 5$

$v^2 = 100$

$v = 10$m/s

$\therefore \quad s = ut + \frac{1}{2}at^2 \quad$ [For stone A]

$(h - 5) = 10t + \frac{1}{2} \times 10 \times t^2$

$h - 5 = 10t + 5t^2$ --------(i)

$\therefore \quad s = ut + \frac{1}{2}at^2 \quad$ [For stone B]

$x = 0 + \frac{1}{2} \times 10 \times t^2$

$(h - 5) - 20 = 5t^2$

$h - 5 = 5t^2 + 20 \quad$ …(ii)

Now, from equation (i) and (ii)

$10t + 5t^2 = 5t^2 + 20$

$t = 2$ sec

from eqn (ii)

$\therefore \quad h - 5 = 5 \times (2)^2 + 20$

$h - 5 = 40$

$h = 45$

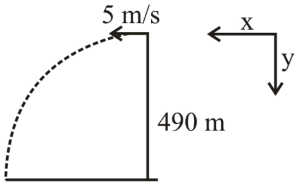
581. A hiker stands on the edge of a cliff 490m above the ground and throws a stone horizontally with and initial speed of 15 m.s^{-1} The speed with which it hits the ground is ______

(a) 99 m.s^{-1} (b) 101 m.s^{-1}

(c) 103 m.s^{-1} (d) 105 m.s^{-1}

AP EAMCET-20.08.2021, Shift-II

Ans. (a) :



Given,

$u = 15$ m/s

$a = g = 9.8$ m/s^2

We know that

$s = ut + \frac{1}{2}at^2$

Applying along y direction, (u = 0)

$490 = 0 + \frac{1}{2}9.8 \times t^2$

$\therefore t = 10$sec

Let v_x & v_y be horizontal & vertical component of velocity respectively when it hits the ground,

$v_y = u_y - gt$

$v_y = 9.8 \times 10 = 98$ m/s

$v_x = u_x = 15$ m/s

$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(15)^2 + (98)^2}$

$v = 99.14$ m/s

582. A body initially lying at a point (3,7) starts moving with a constant acceleration of 4i. Its position after 3 seconds is______

(a) (3,7) (b) (7,18)

(c) (7,3) (d) (21,7)

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (d) : The initial coordinate of the particle is (3,7)

X – Coordinate is 3 unit

Y – Coordinate is 7 unit

As the body starts from rest so initial velocity = 0

The acceleration of the body along X-axis = 4unit

The acceleration of the body along Y-axis = 0

So, after 3 seconds,

Using equation of motion along x-axis,

$x = x_0 = ut + \frac{1}{2}at^2$

$s = 3 + x_0$

As u = 0, a = 4 units, t = 3 seconds

$s = 3 + 0 \times 3 + \frac{1}{2} \times 4 \times 3^2 = 21$ units

As there is no motion along y-axis so it will remain unchanged

Hence, the final coordinate is (21, 7)

583. A body initially lying at a point (3,7) starts moving with a constant acceleration of 4i. Its position after 3 seconds is______

(a) (3,7) (b) (7,18)

(c) (7,3) (d) (21,7)

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (d) : The initial coordinate of the particle is (3,7)

X – Coordinate is 3 unit

Y – Coordinate is 7 unit

As the body starts from rest so initial velocity = 0

@apna_pdf

The acceleration of the body along X-axis = 4unit
The acceleration of the body along Y-axis = 0
So, after 3 seconds,
Using equation of motion along x-axis,

$x=x_0 = ut + \frac{1}{2}at^2$

$s=3+x_0$

As u = 0, a = 4 units, t = 3 seconds

$s = 3 + 0 \times 3 + \frac{1}{2} \times 4 \times 3^2 = 21$ units

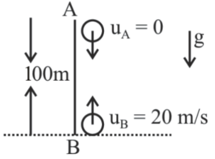
As there is no motion along y-axis so it will remain unchanged
Hence, the final coordinate is (21, 7)

584. An object is dropped from a tower 100m high. Another is projected upward with a velocity of 20m/s. The time taken for them to collide is

(a) 1 sec (b) 5 sec
(c) 2 sec (d) can't be determined

MHT-CET 2020

Ans. (b) : According to the question



Let,

$s_1 = x, \quad u_2 = 20$ m/s
$u_1 = 0, \quad s_2 = 100 - x$

Ist object,

$$s_1 = u_1 t + \frac{1}{2}gt^2$$

$$x = 0 + \frac{1}{2}gt^2$$

$$x = \frac{1}{2}gt^2 \text{ .... (i)}$$

IInd object,

$$100 - x = 20 \times t - \frac{1}{2}gt^2$$

$$100 - x = 20t - \frac{1}{2}gt^2 \text{ .... (ii)}$$

Putting value of x in equation (ii), we get

$$100 - \frac{1}{2}gt^2 = 20t - \frac{1}{2}gt^2$$

$100 = 20t$
$t = 5$ sec

585. Consider that a truck is moving initially with 54 km/h. It has stopped by the driver after looking at an obstacle with a deceleration of 10 m/s^2. The distance travelled by truck before coming to rest is

(a) 12 m (b) 11.25 m
(c) 11.30 m (d) 11.20 m

TS-EAMCET.11.09.2020, Shift-2

Ans. (b) : Given that,

$$u = 54 \text{ km/h} = 54 \times \frac{5}{18} = 15 \text{m/s}$$

$v = 0$
$a = -10$ m/s^2 (due to deceleration)
$s = ?$

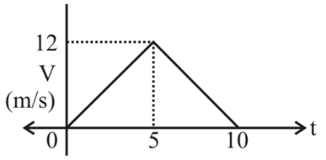
Using Newton's Third Equation,

$v^2 = u^2 + 2as$
$0^2 = (15)^2 + 2 \times (-10) \times s$

$$s = \frac{225}{20}$$

$s = 11.25$ m

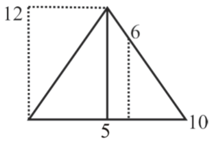
586. The following figure shows the speed-time graph of a particle moving along a fixed direction. The distance travelled by the particle between time $t = 0$s to $t = 6$ s is



(a) 50.2 m (b) 60.8 m
(c) 30.6 m (d) 40.8 m

TS EAMCET 28.09.2020, Shift-I

Ans. (d) :



u = 12m/sec

Now, $s_1 = ut + \frac{1}{2}at^2$

$$= 0 \times 5 + \frac{1}{2} \times a \times (5)^2$$

$$s_1 = \frac{1}{2}a(25)$$

$\because \quad v = u + at$

$12 = 5 \times a$

$a = 2.4$

$\therefore \quad s_1 = \frac{1}{2} \times 2.4 \times 25$

$= 30$

$$s_2 = ut - \frac{1}{2}at^2$$

$$= 12 \times 1 - \frac{1}{2} \times 2.4(1)^2$$

$= 12 - 1.2 = 10.8$

$\therefore \quad$ total distance $= s_1 + s_2$
$= 30 + 10.8 = 40.8$

The travelled distance from the particle from 0 to 6 sec is 40.8 m.

587. The position of an object moving along x-axis is given as $x = a + bt^2$, where a, b are constants and t is time in seconds. The object covers a distance of 16 m in 2 secs. If the average velocity of the object between t = 3 and t = 5 s is 28 m/s. the values of a and b are :

@apna_pdf

(a) 2 m. 3.5 m/s^2 (b) 4 m. 3 m/s^2
(c) 6 m. 2.5 m/s^2 (d) 0 m. 4 m/s^2

TS EAMCET 28.09.2020, Shift-I

Ans. (a) : Given,
Position of moving object,

$x = a + bt^2$................................(I)

Distance covered in 2 sec. = 16 m

$16 = a + 4b$.............................(II)

Average velocity of the object = 28m/sec.
differentiation of position.

$$\frac{dx}{dt} = \frac{d}{dt}\left(a + bt^2\right)$$

$$\because \frac{dx}{dt} = v$$

$$\therefore v = 2bt \text{.................................(III)}$$

So, velocity in 3 sec. and 5 sec.

$v_{at\ 3} = 2 \times b \times 3$

$v_{at\ 3} = 6\ b$

$v_{at\ 5} = 2\times b\times 5 = 10b$

Average Velocity

$$= \frac{v_{at3} + v_{at5}}{2}$$

$$28 = \frac{6b + 10b}{2}$$

$28 = 8\ b$

$$b = \frac{28}{8}$$

$b = 3.5$

Value of b put into the equation second

$16 = a + 4\times b$

$16 = a + 4\times 3.5$

$16 = a + 14$

$a = 2$

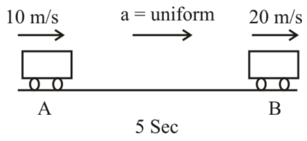
The value of a and b are 2 meter and 3.5 meter/sec.^{2}

588. The velocity of a body moving with uniform acceleration at a given instant of time 't' is 10 m.s^{-1}. Five seconds later its velocity is 20 m.s^{-1}. The distance travelled in that time is:

(a) 75 m (b) 150 m
(c) 300 m (d) 500 m

AP EAMCET-23.09.2020, Shift-II

Ans. (a) :



$v = u + at$

$20 = 10 + a \times 5$

$a = 2\ m/s^2$

Now as we know,

$v^2 = u^2 + 2as$

$20^2 = 10^2 + 2 \times 2 \times s$

$400 = 100 + 4s$

$$s = \frac{300}{4}, \quad s = 75\ m$$

589. A body moving with uniform acceleration describes 12 m in the 3 s of its motion and 20 m in the 5 s. The velocity after 10 s is

(a) 52 m/s (b) 50 m/s
(c) 42 m/s (d) 40 m/s

CG PET 2019

Ans. (c) : As we know that,
Distance travelled in the tth second is
Given by

$$s_t = u + a\left(t - \frac{1}{2}\right)$$

In first case, t = 3, s = 12 m (given)

$$\text{So} \quad 12 = u + a\left(3 - \frac{1}{2}\right)$$

$$12 = u + \frac{5}{2}a \quad \text{...(i)}$$

In the second case, t = 5, s = 20 m (given)

$$\text{So, } 20 = u + a\left(5 - \frac{1}{2}\right)$$

$$20 = u + \frac{9}{2}a \quad \text{...(ii)}$$

From equation (i) and equation (ii) we get,

$a = 4\ m/s^2$

On putting the value of a in eq^n (i)
We get,

$$12 = u + \frac{5}{2} \times 4$$

$12 = 10 + u \Rightarrow u = 2\ m/s$

From the first equation of motion

$v = u + at$

$v = 2 + 4 \times 10 \Rightarrow v = 42\ m/s$

Hence velocity after 10 sec is 42 m/s

590. A particle A moves along the line, y = 30 m with a constant velocity, v parallel to x-axis. At the moment particle A passes the y-axis, a particle B starts from the origin with zero initial speed and a constant acceleration, a = 0.40 m/sec^2. The angle between a and y-axis is 60^o. If the particles A and B collide after sometimes, then the value of |v| will be

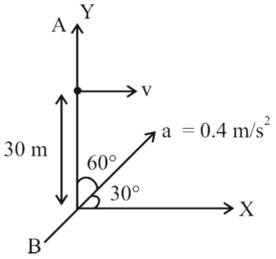
(a) 2 m/s (b) 3 m/s
(c) 4 m/s (d) 5 m/s

TS-EAMCET-04.05.2019, Shift-1

Ans. (b) : Given,

$y = 30\ m$

Vertical component of acceleration of particle
B = a cos 60°



@apna_pdf

Horizontal component of acceleration = a cos 30°
For particle A, acceleration of A = horizontal
Component of acceleration of particle B = a cos 60°
Thus, using equation of motion –

$$s = ut + \frac{1}{2}at^2$$

$$30 = 0 + \frac{1}{2}a\cos 60° \times t^2$$

$$30 = \frac{0.4}{2} \times \frac{1}{2} \times t^2$$

$$t^2 = 300$$

Or $t = \sqrt{300} = 10\sqrt{3}\,\text{sec}$

In $10\sqrt{3}$ sec, they travelled equal distance in x – axis

So, $ut = \frac{1}{2}a\cos 30° t^2$

$$u = \frac{1}{2}a\cos 30° t$$

$$u = \frac{1}{2} \times 0.4 \times \frac{\sqrt{3}}{2} \times \sqrt{300}$$

$$u = 0.1 \times \sqrt{900}$$

$$u = 0.1 \times 30$$

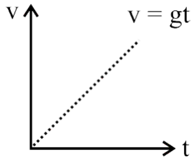
$$u = 3\ \text{m/s}$$

591. The nature of a graph drawn for a freely falling body with time on the x-axis and speed on the y-axis is (Assuming initial speed to be zero.)

(a) A straight line with positive y-axis intercept.
(b) A straight line passing through the origin.
(c) A parabola.
(d) A straight line parallel to y-axis with positive x-axis intercept.

TS-EAMCET-04.05.2019, Shift-1

Ans. (b) : As we know that,



$v = u + gt$

∵ Initial velocity (u) = 0

∴ $v = gt$

This equation shows that a straight line passing through the origin.

592. A body starts from rest, under the action of an engine working at a constant power and moves along a straight line. The displacement S is given as a function of time (t) as

(a) $S = at + bt^2$, a and b are constants
(b) $S = bt^2$, b is a constant
(c) $S = at^{3/2}$, a is a constant
(d) $S = at$, a is a constant

WB JEE 2019

Ans. (c) : We know,

$$P = \frac{\Delta KE}{\Delta t}$$

$$P = \frac{\frac{1}{2}mv^2}{t}$$

Therefore, $v \propto \sqrt{t}$

$$\frac{dS}{dt} \propto \sqrt{t}$$

Integrating both side,

$$S \propto \frac{t^{3/2}}{3/2}$$

$S = at^{3/2}$, a is constant

593. In a car race on a straight path, car A takes a time t less than car B at the finish and passes finishing point with a speed 'v' more than that of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively. Then 'v ' is equal to

(a) $\frac{2a_1a_2}{a_1+a_2}t$
(b) $\sqrt{2a_1a_2}\,t$
(c) $\sqrt{a_1a_2}\,t$
(d) $\frac{a_1+a_2}{2}t$

JEE Main-09.01.2019, Shift-II

Ans. (c) : Let A takes t_1 second then according to the given problem B will take $(t_1 + t)$ seconds,
Then the velocity of A will be $(v_1 + v)$.
Writing equations of motion for A and B.
$v_1 + v = a_1 t_1$ ------- (i)
$v_1 = a_2 (t_1 + t)$ ------(ii)
From these two equations, we get
$v = (a_1 - a_2) t_1 - a_2 t$ ----- (iii)
Total distance travelled by both the cars is equal.
$S_A = S_B$

$$\Rightarrow \frac{1}{2}a_1 t_1^2 = \frac{1}{2}a_2(t_1+t)^2$$

$$\Rightarrow t_1 = \frac{\sqrt{a_2}.t}{\sqrt{a_1} - \sqrt{a_2}}$$

Substituting this value of t_1 in equation (iii),
$v = \sqrt{a_1 a_2}.t$

594. A boy can throw a ball obliquely to a maximum horizontal distance 'x' while standing on the ground. If he throws the same ball from the top of a tower of height 'x' at an angle of 45° above the horizontal from the foot of the tower, the ball hits the ground at a distance
(Assume same initial speeds)

(a) $x\left(1+\sqrt{2}\right)$
(b) $\frac{x}{2}\left(1+\sqrt{3}\right)$
(c) $x\left(1+\sqrt{4}\right)$
(d) $\frac{x}{2}\left(1+\sqrt{5}\right)$

AP EAMCET-24.04.2019, Shift-II

@apna_pdf

Ans. (d) : Maximum horizontal distance range of projectile,

$$R_{max} = \frac{u^2 \sin 2\theta}{g}$$

At $\theta = 45^o$, $R_{max} = x$

$$x = \frac{u^2}{g}$$

$$\therefore u^2 = xg \Rightarrow u = \sqrt{xg} \qquad \ldots\ldots(i)$$

Now, the time of flight, when the ball reaches ground,

$$S = u\sin\theta \times T - \frac{1}{2}gT^2$$

$$-x = \sqrt{\frac{xg}{2}}T - \frac{1}{2}gT^2$$

$$\Rightarrow \frac{1}{2}gT^2 - \sqrt{\frac{xg}{2}}\ T - x = 0 \quad \left[\begin{array}{l}\because u = \sqrt{xg} \\ \text{and} \sin 45 = \frac{1}{\sqrt{2}}\end{array}\right]$$

$$\therefore T = \frac{\sqrt{\frac{xg}{2}} + \sqrt{\frac{xg}{2} + 4\frac{1}{2}gx}}{2.\frac{1}{2}.g}$$

On solving,

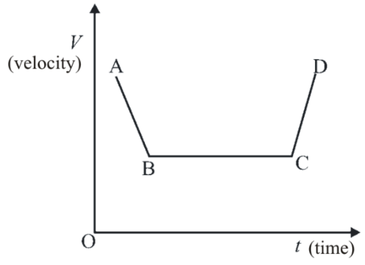
$$T = \frac{\sqrt{\frac{xg}{2}}\left(1+\sqrt{5}\right)}{g}$$

Now, $$R = \sqrt{xg}\cos 45^o \frac{\sqrt{\frac{xg}{2}}\left(1+\sqrt{5}\right)}{g}$$

$$R = \sqrt{xg}\frac{1}{\sqrt{2}}\frac{\sqrt{\frac{xg}{2}}\left(1+\sqrt{5}\right)}{g}$$

$$R = \frac{x}{2}\left(1+\sqrt{5}\right)$$

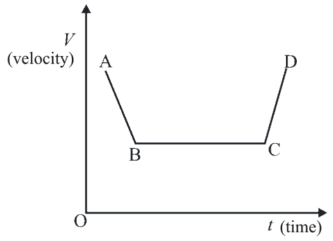
595. In the given velocity (*V*) versus time (*t*) graph, accelerated and decelerated motions are respectively represented by line segments



(a) CD and BC
(b) BC and AB
(c) CD and AB
(d) AB and CD

NDA (I) 2019

Ans. (c) :



$$\text{Acceleration } a = \frac{v_2 - v_1}{t_2 - t_1}$$

A–B – velocity decreasing with time

t ↑ es velocity decreases

AB– deceleration

BC– velocity is constant with respect to time

C–D – velocity is increasing with respect time

CD– Acceleration

596. Consider a vehicle moving with a velocity 54 km/h. At a distance of 400 m, from the traffic light brakes are applied. The acceleration of the vehicle, after the application of brakes is –0.3 m/s^2. The vehicle's position relative to the traffic light is

(a) 25 m
(b) 375 m
(c) 425 m
(d) 30 m

TS-EAMCET-07.05.2018, Shift-1

Ans. (a) : Given that,

u = 54 km/h = 15 m/s

d = 400 m

$a = -0.3$ m/s^2 (due to breaking a = –ve)

Using Newton's equation

$$v^2 = u^2 + 2as$$

$$0 = (15)^2 + 2 \times (-0.3) \times s$$

$$s = \frac{225}{0.6} = 375$$

s = 375 m

Thus vehicle's position relative to the traffic light –

= 400 – 375

= 25 m.

597. A particle starts from origin at time *t* = 0 and moves in positive *x*-direction. Its velocity v varies with times as $v = 10t\hat{i}$ cm/s. The distance covered by the particle in 8 s will be

(a) 320 cm
(b) 80 cm
(c) 120 cm
(d) 640 cm

TS-EAMCET-04.05.2018, Shift-2

Ans. (a) : Given that,

u = 0, $\qquad v = 10t\,\hat{i}$ cm/s

Then at (t) = 8s, $\qquad$ Distance (s) = ?

$$v = 10t\,\hat{i}\ \text{cm/s}$$

$$\frac{dx}{dt} = 10t\ \hat{i}$$

$$dx = 10t\ dt\ \hat{i}$$

@apna_pdf

Partial integration

$$x = \int_0^8 10t\ dt$$

$$x = 5t^2$$

$$x = 320 \text{ m}$$

598. A car starts from rest and moves with a constant acceleration of 5 m/s^2 for 10 s before the driver applies the brake. It then decelerates for 5 s before coming to rest, then the average speed of the car over the entire journey of the car is

(a) 23 m/s (b) 30 m/s
(c) 33 m/s (d) 25 m/s

TS-EAMCET-05.05.2018, Shift-1

Ans. (d) : Given that,

car starts from rest i.e $u = 0$

$a = 5$ m/s^2

at first car moved for 10 sec

So distance covered by car is

$$s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2} \times 5 \times 10^2$$

$$= \frac{5 \times 100}{2} = 250 \text{ m}$$

Then final velocity of the car

$v = u + at = 0 + 5 \times 10$

$v = 50$ m/s

After it, the car started deceleration for further 5 sec before at rest.

Now when it get rested

$v' = 0, \quad u = v = 50$ m/s

Using first equation of motion, we get,

$v' = u + a't$

$0 = 50 + a' \times 5$

$a' = -10$ m/s^2

Using third equation of motion,

$v'^2 = u'^2 + 2a's'$

$v'^2 - u'^2 = 2a's'$

$$s' = \frac{v'^2 - u'^2}{2a'}$$

$$= \frac{0 - 50^2}{2 \times (-10)} = \frac{2500}{20} = 125 \text{ m}$$

$$\text{Thus average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{s + s'}{10 + 5} = \frac{250 + 125}{15} = \frac{375}{15} = 25 \text{ m/s}$$

599. A body travels in a straight line from point A to point B with an initial velocity zero and uniform acceleration, covering 1m during the first second and 39 m during the last second. The distance between A and B in metre is

(a) 50 (b) 100
(c) 390 (d) 400

TS-EAMCET-05.05.2018, Shift-2

Ans. (d) : Given that, $u = 0$

Distance travelled in first 1 sec = 1 m

$$s = ut + \frac{1}{2}at^2$$

So, $$ut + \frac{1}{2}at^2 = 1$$

$$0 + \frac{1}{2}at^2 = 1$$

$$at^2 = 2$$

$$a(1)^2 = 2$$

$$a = 2 \text{m/s}^2$$

final velocity after 1 sec :

$v_1 = u + at$

$= 0 + 2 \times 1$

$v_1 = 2$ m/s

Distance travelled in last 1 sec = 39 m

$$ut + \frac{1}{2}at^2 = 39$$

$$u \times 1 + \frac{1}{2} \times (2) \times (1)^2 = 39$$

$$u + 1^2 = 39$$

$$u = 38 \text{m/s} = v_2$$

acceleration,

$$a = \frac{v_2 - v_1}{t} \Rightarrow t = \frac{v_2 - v_1}{a} = \frac{38 - 2}{2}$$

$t = 18$ sec

Distance travelled in 18 sec is given by

$$s = ut + \frac{1}{2}at^2$$

$$= 2 \times 18 + \frac{1}{2} \times (2) \times 18^2$$

$= 36 + 324 = 360$ m

So, total distance travelled

$= 1 + 39 + 360 = 400$ m

600. A metro train starts from rest and in 5 s achieves speed of 108 km/h. After that it moves with constant velocity and comes to rest after travelling 45 m with uniform retardation. If total distance travelled is 395 m, find total time of travelling.

(a) 12.2 s (b) 15.3 s
(c) 9 s (d) 17.2 s

AIIMS-27.05.2018(E)

Ans. (d) : Given that,

Initial velocity, $u = 0$, $t = 5$sec

$$v = 108 \text{ km/hr} = 108 \times \frac{5}{18} \text{ m/sec} = 30 \text{ m/sec}$$

distance travelling with uniform retardation s_2=45m

First equation of motion

$v = u + at$

$30 = 0 + a \times 5$

$a = 6$ m/s^2

@apna_pdf

Distance travelled in first 5 sec.

$s_1 = \frac{1}{2}at^2$ (From second equation of motion)

$= \frac{1}{2} \times 6 \times 5^2 = 75\text{m}$

Distance travelled with uniform speed of 30 m/s is

$s_1 + s_2 + s_3 = 395$ m

$75 + 45 + s_3 = 395$ m

$s_3 = 275$ m

Time taken to travel 275 m

$$t = \frac{\text{distance}}{\text{speed}} = \frac{275}{30} = 9.2 \text{ sec}$$

for retarding motion.

$v = 0$

$u = 30$ m/s

third equation of motion

$$v^2 - u^2 = -2as$$
$$0 - (30)^2 = -2 \times a \times 45$$
$$a = -10\text{m/s}^2$$

$$s = ut + \frac{1}{2}at^2$$

$$45 = 30 \times t + \frac{1}{2}(-10) \times t^2 \Rightarrow 5t^2 - 30t + 45 = 0$$

$$(t-3)^2 = 0$$

$t = 3$sec.

Total time taken = 5 + 9.2 + 3 = 17.2 sec

601. A balloon rises from rest with a constant acceleration of g/8. A stone is released from it when it has risen to a height h. The time taken by the stone to reach the ground is

(a) $4\sqrt{\frac{h}{g}}$

(b) $2\sqrt{\frac{h}{g}}$

(c) $\sqrt{\frac{2h}{g}}$

(d) $\sqrt{\frac{g}{h}}$

BCECE-2017

Ans. (b) : Given that,

$u = 0$ (rest)

$a = g/8$

3^{rd} eq^n of motion,

$$v^2 = u^2 + 2as$$
$$v^2 = 0 + 2as$$
$$v = \sqrt{2 \times (g/8) \times h}$$
$$v = \frac{\sqrt{gh}}{2}$$

When the stone released from this balloon, the velocity of balloon at height h, is–

$$v = \frac{\sqrt{gh}}{2}$$

In this condition, time taken by stone to reach the ground.

$$s = ut - \frac{1}{2}gt^2$$

$$-h = \frac{\sqrt{gh}\,t}{2} - \frac{1}{2}gt^2 \quad \text{(multiplying 2/g in both side)}$$

$$-h \times \frac{2}{g} = \frac{\sqrt{gh} \times t}{2} \times \frac{2}{g} - \frac{1}{2}gt^2 \times \frac{2}{g}$$

$$-\frac{2h}{g} = \frac{t}{g}\sqrt{gh} - t^2, \quad t = 2\sqrt{\frac{h}{g}}$$

602. The driver of an express trains suddenly sees the red light signal 50m ahead and applies the brakes. If the average deceleration during braking is 10.0 ms^{-2} and the reaction time of the driver is 0.75 sec, the minimum speed at which the train should be moving so as not to cross the red signal is

(a) 27Km/hr

(b) 115Km/hr

(c) 72Km/hr

(d) 83Km/hr

TS EAMCET(Medical)-2017

Ans. (*): Displacement of train in 0.75 sec will be

$s_1 = ut = 0.75$ u

where u = initial velocity of train

$v^2 = u^2 + 2$ as

$v = 0$ ms^{-1}, $s = 50 - s_1$

$u^2 - 2 \times 10 \times (50 - 0.75u) = 0$

$u^2 + 14u - 1000 = 0$

$$u = \frac{-14 \pm 64.77}{2}$$

$u = 39.38 \approx 40\text{m/s}$

u = 144 km/hr

Note – The correct answer is 144 km/ hr, which is not given in the option

603. The x and y coordinates of the particle at any time are x = 5t −2t^2 and y =10t respectively, where x and y are in metres and t in seconds. The acceleration of the particle at t = 2s is

(a) 0

(b) 5 m/s^2

(c) –4 m/s^2

(d) –8 m/s^2

[NEET 2017]

Ans. (c) : Given,

$x = 5t - 2t^2$-------------(1)

$y = 10t$------------------(2)

From equation (1)-

$$v = \frac{dx}{dt} = 5 - 4t$$

$$\text{Acceleration } (a_x) = \frac{d^2x}{dt^2} = -4$$

From equation (2)-

$$v_y = \frac{dy}{dt} = 10$$

$$a_y = \frac{d^2y}{dt^2} = 0$$

Now, $a_R = \sqrt{(a_x)^2 + (a_y)^2}$

$$a_R = \sqrt{(-4)^2 + 0}$$

$$a_R = \pm 4\text{m/s}^2$$

@apna_pdf

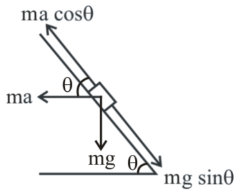
604. A body kept on a smooth inclined plane having inclination 1 in s will remain stationary relative to inclined plane if the body is given a horizontal acceleration equal to

(a) $\frac{g}{\sqrt{s^2-1}}$ (b) $\frac{gs}{\sqrt{s^2-1}}$

(c) $\frac{g\sqrt{s^2-1}}{s}$ (d) $g\sqrt{s^2-1}$

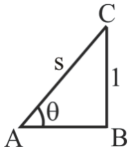
SCRA-2013

Ans. (a) : Body at stationary



ma cos θ = mg sinθ

Acceleration, a = g tanθ ……...(i)



Given, $\sin\theta = \frac{1}{s}$

$$\tan\theta = \frac{1}{\sqrt{s^2-1}} \quad \text{....(ii)}$$

On putting value of eq. (ii) in eq. (i) we get

$$a = \frac{g}{\sqrt{s^2-1}}$$

605. A particle of mass m is at x = 0 with velocity v = u in the x-direction at t = 0, It is subjected to a friction force –bv, where b is a positive constant.
The position of the particle at t → ∞ is

(a) mu/b (b) u/mb

(c) 2mu/b (d) mu/2b

SCRA-2013

Ans. (a) : Given,

Velocity, v = u

F = –bv

Force, F = ma

$$a = \frac{F}{m} = \frac{-bv}{m}$$

Initial acceleration, $a_i = \frac{-bu}{m}$ (at t = 0, v = u)

Final acceleration, $a_f = \frac{-bv}{m}$ (at t → ∞, v = 0)

$$= \frac{-b\times 0}{m}$$

$a_f = 0$

So,

$$\text{Avg. Acceleration } (a_{avg}) = \frac{\frac{-bu}{m}+0}{2}$$

$$a_{avg} = \frac{-bu}{2m}$$

Now,

$$v^2 = u^2 + 2as$$

$$0 = u^2 - 2\times\frac{bu}{2m}\times s$$

$$u^2 = \frac{bu}{m}\times s \Rightarrow s = \frac{mu}{b}$$

606. A car accelerates at 5 ms^{-2} and then retards to rest at 3 ms^{-2} the maximum velocity of the car is 30 m/s. The distance covered by the car is

(a) 150 m (b) 240 m

(c) 300 m (d) 360 m

SCRA-2013

Ans. (b) : Given,

$a_1 = 5\ m/s^2$, $a_2 = -3 m/s^2$

$v_1 = 30$ m/s

$u_1 = 0$

Now, $v_1^2 = u_1^2 + 2a_1s_1$

$30^2 = 0 + 2\times 5\times s_1$

$s_1 = 90$m

Distance travelled during retardation,

$v_2^2 = u_2^2 - 2a_2\,s_2$

∵ $v_2 = 30$, $u_2 = 0$ m/s, $a_2 = -3\ m/s^2$

$(30)^2 = 0^2 - 2\times(-3)\times s_2$

$s_2 = 150$ m

Hence, total distance travelled is,

$s = s_1 + s_2$

$s = 90 + 150 \Rightarrow s = 240$ m

607. A boy desires to hit a bird on the ground from a point at a horizontal distance of 100 m. If the gun can impart a velocity of 500 m/s to the bullet, at what height above the bird must he aim his gun in order to hit it (g = 10m/s^2) ?

(a) 10 cm (b) 20 cm

(c) 50 cm (d) 100 cm

SCRA-2013

Ans. (b) : Given,

Distance, d = 100 m

Velocity, v = 500 m/s

$$t = \frac{d}{v} = \frac{100}{500} = 0.2\,\text{sec}$$

Now, vertical distance covered in 0.2 sec

$$s = ut + \frac{1}{2}gt^2$$

$$s = 0\times t + \frac{1}{2}\times 10\times(0.2)^2$$

s = 0.2 m

or s = 20 cm

@apna_pdf

608. A particle moves in x-y plane with velocity $\vec{v} = a\hat{i} + bx\hat{j}$ where a, b are constants. Initially the particle was locate at x = 0 and y = 0. What is the equation of trajectory of the particle?

(a) $ay = bx^2$ (b) $by = ax^2$
(c) $2ay = bx^2$ (d) $ay = 2bx^2$

SCRA-2012

Ans. (c) : Given,

$$\text{Velocity } (\vec{v}) = a\hat{i} + bx\hat{j} \quad \text{.......(i)}$$

$$\vec{v} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} \quad \text{........(ii)}$$

Comparing equation (i) and (ii) we get

$$\frac{dx}{dt} = a \text{ and } \frac{dy}{dt} = bx$$

Now, $\frac{dx}{dt} = a$

Taking integration both side,

$$\int dx = \int a\,dt$$

$$x = at \quad \text{........(iii)}$$

Now,

$$\frac{dy}{dt} = bx$$

$$\int dy = \int bx\,dt$$

$$\int dy = \int b(at)\,dt \quad \text{(from equation (iii)}$$

$$y = ab\left(\frac{t^2}{2}\right)$$

$$y = ab \times \left(\frac{x}{a}\right)^2 \times \frac{1}{2}$$

$$2ay = bx^2$$

609. A particle moves in x-y plane according to the equations x = 4t^2 + 5t + 16 and y = 5t where x, y are in meter and t is in second. What is the acceleration of the particle?

(a) 8 ms^{-2} (b) 12 ms^{-2}
(c) 14 ms^{-2} (d) None of the above

SCRA-2012

Ans. (a) : Given,

$$x = 4t^2 + 5t + 16 \quad \text{.......(i)}$$

$$y = 5t \quad \text{......(ii)}$$

From equation (i)

$$\text{Velocity } (v_x) = \frac{dx}{dt} = (8t + 5)\,m/s$$

$$\text{Acceleration } (a_x) = \frac{d^2x}{dt^2} = 8$$

From equation (ii)

$$v_y = \frac{dy}{dt} = 5$$

$$\vec{a} = a \times \hat{i} + ay\hat{j}$$

$$a_y = \frac{d^2y}{dt^2} = 0$$

Now, $a_{net} = \sqrt{a_x^2 + a_y^2} = \sqrt{8^2 + 0^2} = 8\,m/s$

610. In a lift moving up with an acceleration of 5ms^{-2}, a ball is dropped from a height of 1.25 m. The time taken by the ball to reach the floor of the lift is ...... (nearly) (g = 10ms^{-2})

(a) 0.3 s (b) 0.2 s
(c) 0.16 s (d) 0.4 s

Karnataka CET-2013

Ans. (d) : Given,

a = 5 m/s^2 s = 1.25 m

Acceleration due to gravity (g) = –10 m/s^2

(Because a and g are in opposite direction)

Acceleration of the lift w.r.t ball, $a_{eff} = a - (-g)$

$= 5 - (-10)$

$a_{eff} = 15$ m/s^2

$$\text{Now, } s = ut + \frac{1}{2}a_{eff}t^2$$

$$1.25 = 0 \times t + \frac{1}{2} \times 15 \times t^2$$

$$t^2 = \frac{2 \times 1.25}{15} \Rightarrow \frac{1}{6}$$

$$t^2 = 0.16 \text{ sec}$$

$$t = 0.4 \text{ sec}$$

611. A bullet moving with a speed of 100 ms^{-1} can just penetrate two planks of equal thickness. Then, the number of such planks penetrated by the same bullet when the speed is doubled will be:

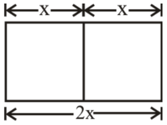
(a) 6 (b) 10
(c) 4 (d) 8

Karnataka CET-2004

Ans. (d) : Given, $n_1 = 2$

$u_1 = 100$m/s

When speed double, $u_2 = 200$m/s



Ist condition,

$$v^2 = u^2 - 2as$$

$$0 = 100^2 - 2a \times 2x$$

$$2a = \frac{-100^2}{2x} \quad \text{...... (i)}$$

IInd condition,

$$v^2 = u^2 - 2as$$

(Let n planks penetrate)

$$0 = (200)^2 - 2a \times nx$$

$$(200)^2 = \frac{100^2}{2x} \times nx$$

Now, $4 = \frac{n}{2}$

So, n = 8 planks

@apna_pdf

612. A car moving with a speed of 50 km/hr can be stopped by brakes, over a distance of 6 m. If the same car is moving at a speed of 100 km/hr. the stopping distance is

(a) 12 m (b) 18 m

(c) 6 m (d) 24 m

J&K CET- 2011

Ans. (d) : Given,

$u_1 = 50$ km/hr $s_1 = 6$ m

$u_2 = 100$ km/hr

$v^2 = u^2 - 2as$

we know that

$0 = u^2 - 2as$ {When car stop, v = 0}

$u^2 = 2as$

$s \propto u^2$ {a is constant}

$$\because \quad \frac{s_1}{s_2} = \frac{u_1^2}{u_2^2}$$

$$\frac{s_1}{s_2} = \frac{50^2}{100^2}$$

$$s_2 = \frac{s_1 \times 100 \times 100}{50 \times 50}$$

$s_2 = s_1 \times 4$

$s_2 = 6 \times 4$

$s_2 = 24$ m

613. A body is moving with uniform acceleration covers 200 m in the first 2 seconds and 220 m in the next 4 seconds. The velocity in m/s after 7 seconds is

(a) 10 (b) 15

(c) 20 (d) 30

J&K CET- 2007

Ans. (a) : Given,

$s_1 = 200$ cm, $s_2 = 220$ cm

$t_1 = 2$ sec, $t_2 = 4$ sec

$t = 7$ sec

Ist condition,

$$s = ut + \frac{1}{2}at^2$$

$$200 = u \times 2 + \frac{1}{2}a(2)^2$$

$$200 = 2u + 2a$$

$$100 = u + a \text{ .... (i)}$$

IInd condition,

$s_3 = s_1 + s_2 = 420$ m, $t_3 = t_1 + t_2 = 2 + 4 = 6$ sec

$$s_3 = ut_3 + \frac{1}{2}at_3^2$$

$$420 = u \times 6 + \frac{1}{2} \times a(6)^2$$

$$420 = 6(u + 3a)$$

$$70 = u + 3a \text{ .... (ii)}$$

From equation (i) and (ii), we get

$$100 - 70 = 4 + a - 4 - 3a$$

$$30 = -2a$$

$$a = -15 \text{ m/s}^2$$

From equation (ii),

$u + 3(-15) = 70$

$u = 115$ m/s

Now,

$v = u + at$

$v = 115 + (-15) \times 7$

$v = 10$ m/s

614. Two balls of same size but the density of one is greater than that of the other are dropped from the same height, then which ball will reach the earth first (air resistance is negligible)?

(a) Heavy ball

(b) Light ball

(c) Both simultaneously

(d) Will depend upon the density of the balls

J&K CET- 2004

Ans. (c) : We know that,

$$s = ut + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2(s - ut)}{g}}$$

Since, s, u and g are same for both,

Hence, both ball will reach the earth in same time.

615. A car moving at 30 m/s slows uniformly to a speed of 10 m/s in a time of 5 seconds. Determine the distance moved in the third second.

(a) 10 m (b) 20 m

(c) 40 m (d) 5 m

J&K CET- 2002

Ans. (b) : Given,

$u_1 = 30 \text{ m/s}$

$u_2 = 10 \text{ m/s}$

$t = 5$ sec

$$\text{Acceleration (a)} = \frac{\text{change in speed}}{\text{Time}} = \frac{30 - 10}{5} = 4 \text{ m/s}^2$$

we know that

$$s = u - \frac{1}{2}a(2t - 1)$$

$$= 30 - 2(2 \times 3 - 1) = 30 - 10 = 20 \text{ m}$$

616. A block slides with a velocity of 10 m/sec on a rough horizontal surface. It comes to rest after covering a distance of 50 m. If g is 10 m/sec^2, then the coefficient of dynamic friction between the block and surface is

(a) 1 (b) 10

(c) 2 (d) 0.1

J&K CET- 2001

@apna_pdf

Ans. (d) : Given,

$u = 10$ m/sec

$s = 50$ m

$v = 0$ m/s

we know that

$v^2 = u^2 - 2as$

$0 = 10^2 - 2 \times a \times 50$

$a = 1$ m/s^2

$\because \quad a = \mu g$

$$\mu = \frac{a}{g}$$

$$\mu = \frac{1}{10}$$

$\mu = 0.1$

617. A ship of mass 3×10^7 kg initially at rest is pulled by a force of 5×10^4 N through a distance of 3 m. Assuming that the resistance due to water is negligible, what will be the speed of the ship?

(a) 0.1 m/s (b) 1.5 m/s

(c) 5 m/s (d) 0.2 m/s

J&K CET- 1999

Ans. (a) : Given,

$m = 3 \times 10^7$ kg

$F = 5 \times 10^4$ N

$s = 3$ m

$$\text{Acceleration (a)} = \frac{F}{m} \qquad (\because F = ma)$$

$$a = \frac{5 \times 10^4}{3 \times 10^7}$$

$$a = \frac{5}{3} \times 10^{-3} \text{ m/s}^2$$

Now,

$v^2 = u^2 + 2as$

$$v^2 = 0 + 2 \times \frac{5}{3} \times 10^{-3} \times 3$$

$v^2 = 10^{-2}$

$v = 0.1$ m/sec

618. The motion of a particle in a straight line is an example of

(a) constant velocity motion

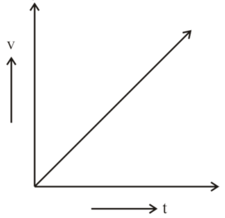
(b) uniformly accelerated motion

(c) non-uniformly accelerated motion

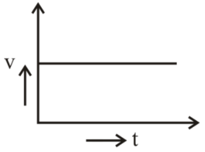
(d) zero velocity motion

J&K-CET-2013

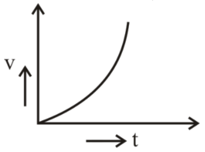
Ans. (b) : Motion of a particle in a straight line is an example of uniformly acceleration motion.



Constant velocity motion



Non-uniformly accelerated motion



619. A constant force F acts on a particle of mass 1 kg moving with a velocity v, for one second. The distance moved in that time is

(a) 0 (b) $\frac{F}{2}$

(c) 2F (d) $\frac{v}{2}$

(e) $v + \frac{F}{2}$

Kerala CEE- 2013

Ans. (e) : Given,

Mass of particle (m) = 1 kg, time = 1sec

Velocity (u) = v

We know that,

Newton second law-

$F = ma$

$$a = \frac{F}{m} = \frac{F}{1} = F$$

$a = F$

From second equation of motion,

$$s = ut + \frac{1}{2} at^2$$

$$s = v \times 1 + \frac{1}{2} \times F \times (1)^2$$

$$s = v + \frac{F}{2}$$

620. A block of mass 10 kg is moving horizontally with a speed of 1.5 ms^{-1} on a smooth plane. If a constant vertical force 10 N acts on it, the displacement of the block from the point of application of the force at the end of 4 s is

(a) 5 m (b) 20 m

(c) 12 m (d) 10 m

(e) 18 m

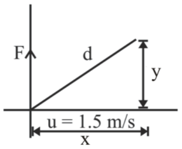
Kerala CEE 2012

Ans. (d) : Given that,

$m = 10$ kg, $u = 1.5$ ms^{-1}

$F = 10$N $t = 4$ s

$s = ?$



@apna_pdf

Horizontal distance (a) = ut = 1.5 ×4

= 6 m

And, given:-

Vertical force = 10 N

Then, $F = ma$

$10 = 10a$

$a = 1\ m/s^2$

And $u = 0$

From equation of motion:-

$$s = ut + \frac{1}{2}at^2$$

$$y = 0(t) + \frac{1}{2} \times 1 \times (4)^2$$

$$y = 8\ m$$

So, displacement (d) = $\sqrt{x^2 + y^2}$

$$= \sqrt{(6)^2 + (8)^2}$$

$$= \sqrt{36 + 64} = \sqrt{100}$$

= 10 m

621. A body moving with a uniform acceleration crosses a distance of 65 m in the 5th second and 105 m in 9th second. How far will it go in 20 s?

(a) 2040 m
(b) 240 m
(c) 2400 m
(d) 2004 m

UPSEE - 2008

Ans. (c) : Distance covered in the second,

$$s_t = u + \frac{1}{2}a(2t - 1)$$

Case 1: $s_t = 65$ m, $t = 5$ sec

So, $$65 = u + \frac{1}{2}a(2 \times 5 - 1)$$

We get,

$$65 = u + \frac{9}{2}a \qquad \text{...(i)}$$

Case 2:

$s_t = 105$ m $t = 9$ sec

So, $$105 = u + \frac{1}{2}a(2 \times 9 - 1)$$

We get,

$$105 = u + \frac{17}{2}a \qquad \text{...(ii)}$$

On subtracting eq. (i) from (ii),

$$105 - 65 = \frac{17}{2}a - \frac{9}{2}a$$

$$40 = \frac{8}{2}a$$

$$a = 10\ m/s^2$$

Now, from eq. (i) –

$$65 = u + \frac{9}{2} \times 10$$

$$65 = u + 45$$

$$u = 20\ m$$

So,

Distance covered in 20 seconds,

$$s = ut + \frac{1}{2}at^2$$

$$s = 20 \times 20 + \frac{1}{2}(10)(20^2)$$

$$s = 2400\ m$$

622. A particle moving along x-axis has acceleration f, at time t, given by $f = f_0\left(1 - \frac{t}{T}\right)$, where f_0 and T are constants. The particle at t = 0 has zero velocity. In the time interval between t = 0 and the instant when f = 0, the particle's velocity (v_x) is

(a) f_0T
(b) $\frac{1}{2}f_0T^2$
(c) f_0T^2
(d) $\frac{1}{2}f_0T$

UPSEE - 2007

Ans. (d) : Given that,

Acceleration of a particle at time t is

$$f = f_0\left(1 - \frac{t}{T}\right) \qquad \text{...(i)}$$

Where, f_0 and T are constant

We know, $f = \frac{dv}{dt}$

So, $$\frac{dv}{dt} = f_0\left(1 - \frac{t}{T}\right)$$

$$dv = f_0\left(1 - \frac{t}{T}\right)dt$$

$$\int dv = f_0\int\left(1 - \frac{t}{T}\right)dt \quad [\text{Integration both side}]$$

$$v = f_0\left(t - \frac{1}{T}\frac{t^2}{2}\right) + c \qquad \text{...(ii)}$$

Where c is integration constant

at t = 0, velocity v = 0

So, $0 = f_0(0 - 0) + c$

$c = 0$

So, equation (ii) becomes,

$$v = f_0\left[t - \frac{1}{T}\frac{t^2}{2}\right] + 0$$

$$v = f_0\left[t - \frac{1}{T}\frac{t^2}{2}\right] \qquad \text{...(iii)}$$

Now at the instant when f = 0, equation (i) becomes,

$$0 = f_0\left(1 - \frac{t}{T}\right) \Rightarrow 1 - \frac{t}{T} = 0$$

$$\Rightarrow \frac{t}{T} = 1$$

$$\Rightarrow t = T$$

@apna_pdf

Putting t = T and v = v_x in equation (iii),

$$v_x = f_0\left[T - \frac{1}{T}\frac{T^2}{2}\right]$$

$$= f_0\left[T - \frac{T}{2}\right]$$

$$v_x = \frac{1}{2}f_0 T$$

623. The velocity acquired by a body moving with uniform acceleration is 30 ms^{-1} in 2 seconds and 60 ms^{-1} in four seconds. The initial velocity is

(a) 4 ms^{-1} (b) 0 ms^{-1}
(c) 2 ms^{-1} (d) 10 ms^{-1}

BITSAT-2008

Ans. (b) : Given that,
at t = 2 s, v = 30 m/s
at t = 4 s, v = 60 m/s

Velocity of a body moving with uniform acceleration is given by
v = u + at
Where u = initial velocity
v = final velocity
a = acceleration
t = time

In case (i) If v = 30 ms^{-1} at t = 2 sec
30 = u + a × 2
30 = u + 2a …(i)

In case (ii) If v = 60 ms^{-1} at t = 4 sec
60 = u + a × 4
60 = u + 4a … (ii)

After solving equation (i) and equation (ii) we get,
a = 15 m/s^2

On putting value of a in equation (i) we get,
30 = u + 15 × 2
u = 0 m/s

Hence, initial velocity is zero.

624. A man runs at a speed of 4 m/s to overtake a standing bus. When he is 6 m behind the door at t = 0, the bus moves forward and continuous with a constant acceleration of 1.2 m/s^2. The man reaches the door in time t. Then,

(a) $4t = 6 + 0.6t^2$ (b) $1.2t^2 = 4t$
(c) $4t^2 = 1.2t$ (d) $6 + 4t = 0.2t^2$

BITSAT-2013

Ans. (a) : Given that,
Speed of a man = 4 m/s
Acceleration of bus = 1.2 m/s^2
Distance between man and standing bus door (d) = 6 m
We know that,
Distance (s) = velocity × time
s = vt
s = 4t
At standing position u = 0
Using the second equation of motion,

$$s - d = ut + \frac{1}{2}at^2$$

$$s = d + ut + \frac{1}{2}at^2$$

$$s = 6 + \frac{1}{2} \times 1.2 \times t^2 \text{---------------} \quad (i)$$

(∵ u = 0 and d = 6)

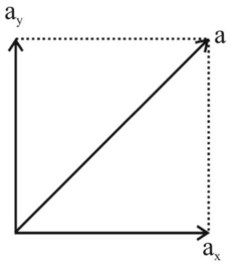
Putting s = 4t in equation (i) –
$4t = 6 + 0.6t^2$

625. A body starts from rest from the origin with an acceleration of 6 m/s^2 along the X-axis and 8 m/s^2 along the Y- axis. Its distance from the origin after 4s will be

(a) 56 m (b) 64 m
(c) 80 m (d) 128 m

CG PET- 2004

Ans. (c) : Acceleration along x-axis, $a_x = 6\ m/s^2$
Acceleration along y-axis, $a_y = 8\ m/s^2$



Resultant acceleration is given by

$$a = \sqrt{a_x^2 + a_y^2}$$

$$a = \sqrt{6^2 + 8^2}$$

$$a = 10\,m/s^2$$

For calculating distance,
Using second equation of motion

$$s = ut + \frac{1}{2}at^2$$

u = 0, distance at time t = 4 sec

$$s = 0 + \frac{1}{2} \times 10 \times 4^2$$

s = 5 × 16 = 80 m
s = 80 m

626. A bullet comes out of the barrel of gun of length 2 m with a speed 80 m/s. The average acceleration of the bullet is

(a) 1.6 m/s^2 (b) 160 m/s^2
(c) 1600 m/s^2 (d) 16 m/s^2

Manipal UGET-2010

Ans. (c) : Given that,
Initial velocity of bullet (u) = 0 m/s
Final velocity of bullet (v) = 80 m/s
Total length of gun = 2 m
Average acceleration of bullet (a) = ?
We know that,
Third equation of motion–
$v^2 = u^2 + 2as$

@apna_pdf

$\because \quad u^2 = 0$

$\therefore \quad v^2 = 2as,$

$$a = \frac{v^2}{2s} = \frac{(80)^2}{2\times 2} = \frac{6400}{4}$$

$a = 1600\ m/s^2$

627. A ball rolls off the top of stairway with a horizontal velocity of magnitude 1.8 m/s. The steps are 0.20 m high and 0.20 m width. Which step will the ball hit first?

(a) First (b) Second

(c) Third (d) Fourth

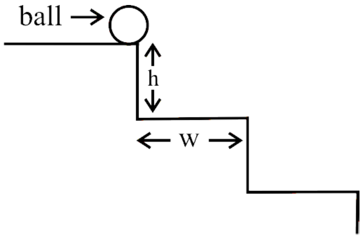
Manipal UGET-2010

Ans. (d) : Given,

Height of the step (h) = 0.20 m

Width of step (w) = 0.20 m

Initial velocity (u) = 1.8 m/s (In Horizontal direction)



Let the ball strikes the nth step of stair

then vertical distance = n.h

From equation of motion –

$$nh = ut + \frac{1}{2}gt^2$$

$$n \times 0.20 = 0 + \frac{1}{2}gt^2$$

$$n \times 0.20 = \frac{1}{2}gt^2 \qquad \ldots(i)$$

Horizontal distance = nw

$n.w = ut$

$$t = \frac{nw}{u}$$

$$t = \frac{n\times 0.20}{u}$$

Put the value of 't' in equation no. (i)

$$n \times (0.20) = \frac{1}{2}\times(9.8)\times\left(\frac{n\times 0.20}{u}\right)^2$$

$$n\times 0.20 = \frac{4.9\times n^2\times 0.20\times 0.20}{u^2}$$

$$n = \frac{u^2}{4.9\times 0.20} = \frac{1.8\times 1.8}{4.9\times 0.20}$$

$n = 3.30 \approx 4$

$n = 4$

628. A body of mass 10 kg is moving with a constant velocity of 10m/s. When a constant force acts for 4 s on it, it moves with a velocity 2m/s in the opposite direction. The acceleration produced in it is

(a) $3\ m/s^2$ (b) $-3 m/s^2$

(c) $0.3\ m/s^2$ (d) $0.03\ m/s^2$

Manipal UGET-2010

Ans. (b) : Given that,

Mass of body (m) = 10 kg

u = 10 m/s

v = –2 m/s (For opposite direction)

t = 4s

a = ?

Using Newton's First equation of motion

$v = u + at$

$-2 = 10 + a \times 4$

$a \times 4 = -12$

$a = -3\ m/s^2$

Hence, the negative sign indicates that direction of force was opposite to the direction of initial velocity.

629. A body starts from rest with uniform acceleration. If its velocity after n second is v, then its displacement in the last 2 s is

(a) $\frac{2v(n+1)}{n}$ (b) $\frac{v(n+1)}{n}$

(c) $\frac{v(n-1)}{n}$ (d) $\frac{2v(n-1)}{n}$

JCECE-2010

Ans. (d) : Given ,

Initial velocity u = 0, acceleration = a , t = n

First equation of motion

$v = u + at$

$v = 0 + an$

$$a = \frac{v}{n} \qquad \ldots (i)$$

distance travelled in n sec,

$$s_n = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2}at^2$$

$$= \frac{1}{2}at^2 = \frac{1}{2}\frac{v}{n}.n^2 \qquad \{\because \text{ by eqn (i)}\}$$

distance travelled in n – 2 sec,

$$s_{n-2} = ut + \frac{1}{2}at^2$$

$$= \frac{1}{2}\times\frac{v}{n}(n-2)^2 = \frac{1}{2}.\frac{v}{n}\left(n^2+4-4n\right)$$

$$s = s_n - s_{n-2} = \frac{1}{2}\frac{v}{n}.n^2 - \frac{1}{2}\frac{v}{n}\left(n^2+4-4n\right)$$

$$= \frac{1}{2}\frac{v}{n}\left(n^2-n^2-4+4n\right) = \frac{1}{2}\frac{v}{n}4(n-1)$$

$$s = \frac{2v}{n}(n-1)$$

@apna_pdf

630. An automobile travelling at 50 km/h, can be stopped at a distance of 40 m by applying brakes. If the same automobile is travelling at 90 km/h, all other conditions remaining same and assuming no skidding, the minimum stopping distance in metres is :

(a) 72 (b) 92.5

(c) 102.6 (d) 129.6

JCECE-2005

Ans. (d) : Given,

Initial velocity, u = 50 km/h

Final velocity, v = 0

Displacement, s = 40m

From equation of motion:-

$v^2 = u^2 - 2as$ (–ve acceleration)

$$a = \frac{u^2}{2s} = \frac{\left(50\times\frac{5}{18}\right)^2}{2\times40}$$

Initial Velocity, u' = 90 km/h

Final velocity, v' = 0

$v'^2 = u'^2 - 2as$

$$s = \frac{u'^2}{2a}(v' = 0)$$

$$= \frac{\left(90\times\frac{5}{18}\right)^2\times2\times40}{2\times\left(50\times\frac{5}{18}\right)^2}$$

s = 129.6 meter,

The minimum stopping distance is 129.6 meter.

631. The velocity of a body moving with uniform acceleration at a given instant of time t is 10 m/s. After 5 s its velocity is 20 m/s. Distance travelled in that time is:

(a) 300 m (b) 400 m

(c) 150 m (d) 75 m

JCECE-2004

Ans. (d) : Given,

u = 10 m/s

v = 20 m/s

t = 5 sec.

From, first equation of motion

$v = u + at$

$$a = \frac{v-u}{t} = \frac{20-10}{5} = \frac{10}{5} = 2\text{m/s}^2$$

From, third equation of motion

$v^2 = u^2 + 2as$

$(20)^2 = (10)^2 + 2 \times 2\times s$

$$s = \frac{300}{4} = 75\,\text{meter.}$$

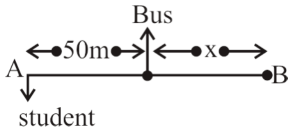
632. A student is standing at a distance of 50 metre from the bus. As soon as the bus begins its motion with an acceleration of 1 ms^{-2}, the student starts running towards the bus with a uniform velocity u. Assuming the motion to be along a straight road, the minimum value of u, so that the student is able to catch the bus is

(a) 8 ms^{-1} (b) 5 ms^{-1}

(c) 12 ms^{-1} (d) 10 ms^{-1}

AIIMS-2010

Ans. (d) :



Distance of bus from student = 50 m

Acceleration of Bus = 1 m/s^2

Velocity of student = u

Let,

Distance covered by the bus from initial position = x

From second equation of motion

$$s = ut + \frac{1}{2}at^2$$

$$x = 0 + \frac{1}{2}\times1\times t^2 \qquad (a = 1)$$

$x = t^2/2$.........(i)

Distance covered by the student

$$s = ut + \frac{1}{2}at^2 \qquad (a = 0)$$

s = ut

(x + 50) = ut ....(ii)

By subtracting eq^n (i) from (ii)

$x + 50 - x = ut - t^2/2$

$50 = ut - t^2/2$

$$u = \frac{t}{2} + \frac{50}{t}\text{........(iii)}$$

Differentiate both side.

$$\frac{du}{dt} = \frac{1}{2} - \frac{50}{t^2} = 0$$

$t^2 - 100 = 0$

t = 10 sec

put the value of t in eq^n (iii) we get

$$u = \frac{10}{2} + \frac{50}{10}$$

= 5 + 5 = 10 m/s

633. If a car at rest accelerated uniformly to a speed of 144 km/hour in 20 second it covers a distance:

(a) 400 m (b) 1440 m

(c) 2880 m (d) 25 m

AIIMS-1997

Ans. (a) : Given that,

u = 0 (car is in rest position)

Speed(v) = 144 km/h

$$= 144 \times \frac{5}{18} = 40\text{m/s}$$

t = 20 sec.

From first equation of motion

v = u + at

$$a = \frac{v-u}{t} = \frac{40-0}{20} = 2\text{m/sec}^2$$

@apna_pdf

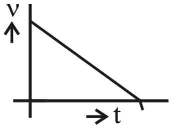
From second equation of motion

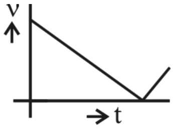
$$s = ut + \frac{1}{2}at^2$$

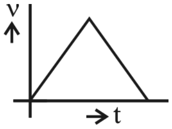
$$= \frac{1}{2}\times 2\times(20)^2 \qquad \begin{bmatrix} u = 0 \\ a = 2 \\ t = 20\,\text{sec.} \end{bmatrix}$$

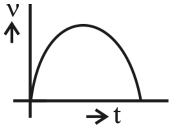
$= 400\text{m}$

634. A ball is thrown vertically upward. Ignoring the air resistance, which one of the following plot represent the velocity time plot for the period ball remains in air?

(a)


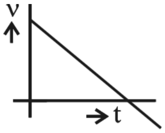
(b)


(c)


(d)


DCE- 2007, 2009

Ans. (a) : $v = u - gt$

correct figure:


During upward position velocity is decreasing and become zero and magnitude of velocity is increasing in downward direction.

635. The acceleration *a* of a particle starting from rest varies with time according to relation $a = \alpha t + \beta$. The velocity of the particle after a time *t* will be

(a) $\frac{\alpha t^2}{2} + \beta$
(b) $\frac{\alpha t^2}{2} + \beta t$
(c) $\alpha t^2 + \frac{1}{2}\beta t$
(d) $\frac{(\alpha t^2 + \beta)}{2}$

DCE-2009

Ans. (b) : Given data,

Acceleration (a) = $\alpha t+\beta$-------(i)

$$\text{As, } a = \frac{dv}{dt}$$

From equation (i)

$$\frac{dv}{dt} = (\alpha t + \beta) \text{ --------(ii)}$$

Integrate above equation

$$\Rightarrow \int_0^v dv = \int_0^t (\alpha t + \beta)dt$$

$$[v]_0^v = \left[\frac{\alpha t^2}{2} + \beta t\right]_0^t$$

$$v = \frac{\alpha t^2}{2} + \beta t$$

636. A particle moves with constant acceleration along a straight line starting from rest. The percentage increase in its displacement during the 4th second compared to that in the 3rd second is

(a) 33%
(b) 40%
(c) 66%
(d) 77%

WB JEE-2014

Ans. (b) : The displacement of the particle in nth second

$$s_n = u + \frac{1}{2}a(2n-1)$$

Given that u = 0

$$s_n = \frac{1}{2}a(2n-1)$$

Thus the displacement in 3rd second

$$s_3 = \frac{1}{2}a(2\times 3-1) = \frac{5a}{2}$$

The displacement in the 4th second

$$s_4 = \frac{1}{2}a(2\times 4-1) = \frac{7a}{2}$$

Percentage increase in the displacement

$$= \frac{s_4 - s_3}{s_3}\times 100$$

$$= \frac{\frac{7a}{2} - \frac{5a}{2}\times 100}{5a/2} = \frac{2a}{2}\times\frac{2}{5a}\times 100 = 40\%$$

637. A particle is travelling along a straight line OX. The distance x (in meter) of the particle from O at a time t is given by $x = 37 + 27t - t^3$, where t is time in seconds. The distance of the particle from O when it comes to rest is

(a) 81 m
(b) 91 m
(c) 101 m
(d) 111 m

WB JEE 2012

Ans. (b) : Given,

Distance, $x = 37 + 27t - t^3$

$$v = \frac{dx}{dt} = 0 + 27 - 3t^2$$

$27 = 3t^2$

$t^2 = 9$

$t = 3$

Then distance travelled.

$x = 37 + 27\times 3 - (3)^3$

$x = 37 + 81 - 27$

$x = 118 - 27$

$x = 91$ m

638. The acceleration a (in ms^{-2}) of a body, starting from rest varies with time t(in s) following the equation a = 3t + 4. The velocity of the body at time t = 2 s will be

(a) 10 ms^{-1}
(b) 18 ms^{-1}
(c) 14 ms^{-1}
(d) 26 ms^{-1}

WB JEE 2009

@apna_pdf

Ans. (c) : Given,

$$a = 3t + 4$$

$$\frac{dv}{dt} = 3t + 4$$

$$\because \quad v = \frac{3}{2}t^2 + 4t$$

At $t = 2\text{sec}$

$$v = \frac{3}{2}(2)^2 + 4(2) = 14\ \text{ms}^{-1}$$

639. A lift starting from rest with a constant upward acceleration moves 1.5m in the 0.4 s. If a person standing in the lift holds a packet of 2 kg by a string then the tension in the string due to motion is

(a) 5.89 N (b) 77.1 N
(c) 6.71 N (d) Non of the above

UP CPMT-2013

Ans. (d) : Given,

$u = 0$
$s = 1.5\text{m}$
$t = 0.4\text{ s}$
$m = 2\text{kg}$

we know that

$$s = ut + \frac{1}{2}at^2$$

$$= 0 \times 0.4 + \frac{1}{2}\ a \times (0.4)^2$$

$$1.5 = a \times 0.08$$

$$a = \frac{1.5}{0.08} = 18.75\text{m/s}^2$$

Total weight of packet

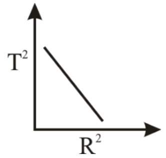
$$T = mg + ma$$

$$= 2\ (9.8 + 18.75)$$

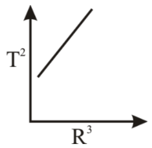
$$\boxed{T = 57.1\text{N}}$$

640. Which of the following graph represents the motion of a planet moving around the sun ?

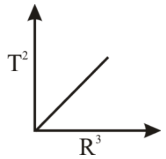
(a)



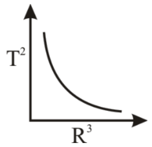
(b)



(c)

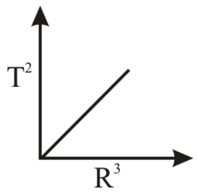


(d)



UP CPMT-2010

Ans. (c) :



Kepler's Third Law :-

The squares of the orbital periods of the planets are directly proportional to the cubes of the semi major axis of their orbits. Kepler's third law implies that the period for a planet to orbit the sun increases rapidly with the radius of its orbit.

According to this law

$$T^2 \alpha R^3$$

641. A stone is dropped from the top of a tower of height 45 m. One second later another stone is thrown down from the top of the same tower. Both stones reach the ground at the same time. If g = 10 m/s^2 magnitude of the initial velocity of the second stone is

(a) 16 m/s (b) 25 m/s
(c) 12.5 m/s (d) 8 m/s

TS EAMCET(Medical)-2015

Ans. (c) : Given,

$H = 45$ m
$g = 10\text{m/s}^2$

For stone 1, u =0

$$H = ut + \frac{1}{2}gt^2$$

$$45 = \frac{1}{2} \times 10 \times t^2 \quad [\therefore u = 0]$$

$$t^2 = \frac{45 \times 2}{10} \Rightarrow t = 3\text{ s}$$

For stone 2, t' = t–1

$$H = u(t-1) + \frac{1}{2}g(t-1)^2$$

$$45 = u\ (3-1) + \frac{1}{2} \times 10(3-1)^2$$

$$45 = 2u + 20 \Rightarrow u = 12.5\text{ m/s}$$

642. Distance travelled by a body falling from rest in the first, second and third second is in the ratio of

(a) 1:2:3 (b) 1:3:5
(c) 1:4:9 (d) None of the above

SRMJEE - 2013

Ans. (b) : Given, initial velocity (u) = 0

Distance travelled in first second

$$s_1 = \frac{1}{2}at^2 = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 1 = 5\text{m} \ ....(i)$$

$$S_2 = u + \frac{1}{2}g(2t-1)$$

$$= 0 + \frac{1}{2} \times 10(2 \times 2 - 1)$$

$$S_2 = 15\text{m}.......(ii)$$

$$S_3 = u + \frac{1}{2}g(2t-1)$$

$S_3 = 25$ m ..... (iii)

from eqn (i), (ii) and (iii)

Now, $s_1 : s_2 : s_3 = 1 : 3 : 5$

@apna_pdf

643. An electron starting from rest has a velocity that increases linearly with time as v = kt, where k = 2 m/s^2. The distance covered in the first 3 seconds will be :

(a) 9 m (b) 16 m
(c) 27 m (d) 36 m

SRMJEE - 2013

Ans. (a) : Given,
Variation of velocity with t is given as v = kt

$$\Rightarrow \frac{dx}{dt} = kt$$

$$\Rightarrow dx = ktdt$$

Distance covered in first 3 seconds will be

$$\int_0^x dx = k\int_0^3 t\,dt$$

$$\Rightarrow x = \frac{1}{2}k\left[t^2\right]_0^3 = \frac{1}{2}\times 2\times 9 \qquad (k = 2m/s^2)$$

$$\therefore x = 9m$$

644. A body moving with uniform acceleration 6 m/s^2 starts from rest. The distance covered by it in 4th second will be

(a) 21 m (b) 35 m
(c) 53 m (d) 12 m

SRMJEE - 2014

Ans. (a) : Given, initial velocity (u) = 0
Acceleration of the body, a = 6 m/s^2
Velocity acquired in first three seconds of the motion

$$v = u + at = 6 \times 3 \text{ m/s} = 18 \text{ m/s}$$

This will be the initial velocity for the last one second of the motion
∴ The distance covered in 4th second

$$s = 18\times 1 + \frac{1}{2}\times 6\times 1^2 = 18 + 3 = 21m$$

645. If a ball is thrown vertically upwards with speed u, the distance covered during the last t sec of its ascent is

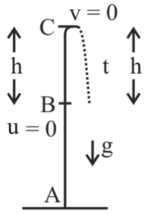
(a) $ut - \frac{1}{2}gt^2$ (b) (u + gt) t
(c) ut (d) $\frac{1}{2}gt^2$

[AIPMT 2003]

Ans. (d) : We know that, $h = ut + \frac{1}{2}gt^2$

$$h = 0 \times t + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2$$



646. A particle moves in a straight line with a constant acceleration. It changes its velocity from 10 ms^{-1} to 20 ms^{-1} while passing through a distance 135 m in t sec. The value of t is

(a) 10 (b) 1.8
(c) 12 (d) 9

[AIPMT 2008]

Ans. (d) : Given, u = 10 m/s, v = 20 m/s, s = 135 m
We know that, v = u + at

$$20 = 10 + at$$

$$a = \frac{10}{t}$$

Now, $s = ut + \frac{1}{2}at^2$

$$135 = 10 \times t + \frac{1}{2}\times\frac{10}{t}(t)^2$$

$$135 = 10t + 5t \Rightarrow 135 = 15t$$

$$t = 9 \text{ sec}$$

647. A particle moves along a straight line such that its displacement at any time t is given by
s = (t^3 − 6t^2 + 3t + 4)m
The velocity when the acceleration is zero, is

(a) 3 ms^{-1} (b) −12 ms^{-1}
(c) 42 ms^{-1} (d) −9 ms^{-1}

[AIPMT 1994]

Ans. (d) : Given, s = (t^3 – 6t^2 + 3t + 4)m

Velocity (v) = $\frac{ds}{dt} = 3t^2 - 12t + 3$------------(1)

Acceleration (a) = $\frac{d^2s}{dt^2} = 6t - 12$

When, a = 0

$$0 = 6t - 12 \Rightarrow t = 2 \text{ sec}$$

From equation (1),

$$v = 3(2)^2 - 12 \times 2 + 3 \Rightarrow v = 12 - 24 + 3$$

$$v = -9 \text{ m/s}$$

648. The position x of a particle w.r.t. time t along x-axis is given by x = 9t^2 − t^3, where x is in metre and t in sec. What will be the position of this particle when it achieves maximum speed along the + x direction?

(a) 32 m (b) 54 m
(c) 81 m (d) 24 m

[AIPMT 2007]

Ans. (b) : Given,

$x = 9t^2 - t^3$------------(1)

speed (v) = $\frac{dx}{dt} = 18t - 3t^2$

Maximum velocity at $\frac{dv}{dt} = 0$,

$$\frac{dv}{dt} = 18 - 6t$$

The time will be-

$$0 = 18 - 6t$$

$$t = 3 \text{ sec}$$

@apna_pdf

From equation (1)

$$x = 9(3)^2 - (3)^3$$
$$x = 81 - 27$$
$$x = 54 \text{ m}$$

649. The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will

(a) decrease with time
(b) be independent of α and β
(c) drop to zero when α = β
(d) increase with time

[AIPMT 2005]

Ans. (d) : Given, $x = ae^{-\alpha t} + be^{\beta t}$

$$\text{Velocity } (v) = \frac{dx}{dt} = ae^{-\alpha t}(-\alpha) + be^{\beta t}(\beta)$$
$$v = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$$
$$\text{Acceleration } (a) = \frac{dv}{dt} = a\alpha^2 e^{-\alpha t} + b\beta^2 e^{\beta t}$$

From this equation, we can say that velocity will increase with time.

650. A particle moves along a straight line such that its displacement at any time t is given by $s = 3t^3 + 7t^2 + 14t + 5$. The acceleration of the particle at t = 1 s is

(a) 18 m/s^2
(b) 32 m/s^2
(c) 29 m/s^2
(d) 24 m/s^2

[AIPMT 2000]

Ans. (b) : Given, $s = 3t^3 + 7t^2 + 14t + 5$

$$\text{Velocity } (v) = \frac{ds}{dt} = 9t^2 + 14t + 14$$
$$(a) = \frac{dv}{dt} = 18t + 14$$

At t = 1 sec,

$$a = 18 \times 1 + 14$$
$$a = 32 \text{ m/s}^2$$

651. The position x of a particle varies with time t, as $x = at^2 - bt^3$. The acceleration of the particle will be zero at time t equals to

(a) zero
(b) $\frac{a}{3b}$
(c) $\frac{2a}{3b}$
(d) $\frac{a}{b}$

AIPMT-1997

Ans. (b) : Given, $x = at^2 - bt^3$

$$\text{Velocity } (v) = \frac{dx}{dt} = 2at - 3bt^2$$
$$a = \frac{dv}{dt} = 2a - 6bt$$

According to question (a = 0)

$$0 = 2a - 6bt$$
$$6bt = 2a$$
$$t = \frac{2a}{6b} \Rightarrow t = \frac{a}{3b}$$

652. If the velocity of a particle is $v = At + Bt^2$, where A and B are constants, then the distance travelled by it between 1s and 2s is

(a) 3A + 7B
(b) $\frac{3}{2}A + \frac{7}{3}B$
(c) $\frac{A}{2} + \frac{B}{3}$
(d) $\frac{3}{2}A + 4B3$

[NEET 2016]

Ans. (b) : Given, $v = At + Bt^2$

$$\text{Velocity } (v) = \frac{ds}{dt}$$
$$ds = vdt\text{-------------}(1)$$

Integrating equation (1)

$$s = \int_1^2 \left(At + Bt^2\right)dt$$
$$s = \left[\frac{At^2}{2} + \frac{Bt^3}{3}\right]_1^2$$
$$s = \frac{A}{2}(2^2 - 1^2) + \frac{B}{3}(2^3 - 1^3)$$
$$s = \frac{3A}{2} + \frac{7B}{3}$$

653. Two forces of magnitude F have a resultant of the same magnitude F. The angle between the two forces is :

(a) 45°
(b) 120°
(c) 150°
(d) 60°

MP PET-2012

Ans. (b) As we know that force is vector quantity and it's resultant would be given as per the formula,

$$\sqrt{A^2 + B^2 + 2AB\cos\theta}$$

Where, θ = Angle between two forces.
According to the question both the forces have magnitude F and resultant F,

So, $F = \sqrt{F^2 + F^2 + 2F.F\cos\theta}$

$$F^2 = 2F^2 + 2F^2 \cos\theta$$
$$-F^2 = 2F^2 \cos\theta$$
$$\cos\theta = -1/2$$
$$\cos\theta = \cos 120^\circ$$
$$\theta = 120^\circ$$

Hence, the force have same magnitude and same resultant then angle between them will be 120°.

654. A Train accelerates from rest at a constant rate α for distance x_1 and time t_1. After that it retards to rest at constant rate β for distance x_2 and time t_2. Which of the following relations is correct?

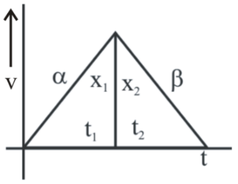
@apna_pdf

(a) $\frac{x_1}{x_2} = \frac{\alpha}{\beta} = \frac{t_1}{t_2}$ (b) $\frac{x_1}{x_2} = \frac{\beta}{\alpha} = \frac{t_1}{t_2}$

(c) $\frac{x_1}{x_2} = \frac{\alpha}{\beta} = \frac{t_2}{t_1}$ (d) $\frac{x_1}{x_2} = \frac{\beta}{\alpha} = \frac{t_2}{t_1}$

MP PET-2012

Ans. (b) :



So, $\alpha = \frac{v_{max}}{t_1}$.........(i) $\beta = \frac{v_{max}}{t_2}$............(ii)

$$\frac{\alpha}{\beta} = \frac{t_2}{t_1}$$

Now, s = area under v–t graph

$$x_1 = \frac{1}{2} \times t_1 \times v_m$$

$$x_2 = \frac{1}{2} \times t_2 \times v_m$$

$$\frac{x_1}{x_2} = \frac{t_1}{t_2} = \frac{\beta}{\alpha}$$

655. An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20m. If the car is going twice as fast, i.e, 120 km/h, the stopping distance will be

(a) 20 m (b) 40 m

(c) 60 m (d) 80 m

AIEEE 2004

Ans. (d) : Given, $u_a = 60$ km/h, $s_a = 20$ m, $v_a = 0$ m/s

$$u_{car} = 120 \text{ km/s} = 120 \times \frac{5}{18} = 33.33 \text{ m/s}$$

$$\because \quad v^2 = u^2 + 2as$$

$$0 = \left(60 \times \frac{5}{18}\right)^2 + 2a(20)$$

$$0 = (16.66)^2 + 40a$$

$$a = 6.94 \text{ m/s}^2$$

Stopping distance (s) = $-\frac{u_{car}^2}{2a}$

$$s = -\frac{(33.33)^2}{2 \times 6.94} = 80.05 \text{ m} \square \ 80 \text{ m}$$

656. A car moving with a speed of 50 km/h, can be stopped by brakes after atleast 6 m. If the same car is moving at a speed of 100 km/h, the minimum stopping distance is

(a) 12 m (b) 18 m

(c) 24 m (d) 6 m

AIEEE 2003

Ans. (c) : Given that,
Speed of car, (u_1) = 50 km/h and stopping distance (s_1) = 6m
Speed of car (u_2)=100km/h
According to Newton's third Law of motion,

$$v^2 = u^2 - 2as \quad \text{(for retardation)}$$

$$0 = u^2 - 2as$$

$$u^2 = 2as$$

$$s \propto u^2$$

[a is constant and negative as considering retardation]

$$\therefore \frac{s_2}{s_1} = \frac{u_2^2}{u_1^2} = \frac{100^2}{50^2}$$

$$s_2 = 4s_1 = 4 \times 6 = 24 \text{ m}$$

657. A staircase has 5 steps each 10 cm high and 10cm wide. What is the minimum horizontal velocity to be given to the ball so that it hits directly the lowest plane from the top of the staircase? (g = 10 ms^{-2})

(a) 2 ms^{-1} (b) 1 ms^{-1}

(c) $\sqrt{2}$ ms^{-1} (d) ½ ms^{-1}

NDA (II) 2012

Ans. (c) : y = 10 cm

x = 10 cm

h = 5

g = 10 m/s^2

Distance travelled is vertical direction

$$y = ut + 1/2\, gt^2$$

$$hy = 1/2\, gt^2$$

$$hy = 1/2 \times 10 \times t^2 = = 5t^2$$

$$t^2 = \frac{5 \times \frac{1}{10}}{5} = \frac{1}{10}$$

$$t = \frac{1}{\sqrt{10}}$$

Distance travelled in the horizontal direction is

$$hx \ \square \ ut$$

$$5 \times \frac{1}{10} = u \times \frac{1}{\sqrt{10}}$$

$$u = \frac{5 \times \sqrt{10}}{10}$$

$$u = \sqrt{2}$$

658. If the distance S covered by a moving car in rectilinear motion with a speed *v* in time *t* is given by *S* = *vt*, then the car undergoes

(a) a uniform acceleration

(b) a non-uniform acceleration

(c) a uniform velocity

(d) a non-uniform velocity

NDA (I) 2014

Ans. (c): Car is moving on rectilinear path motion (straight line)
car follow the equation S = vt
So car moving with constant velocity
Hence, car is in uniform motion.

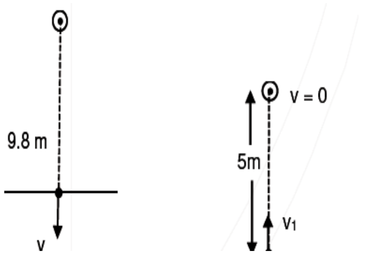
@apna_pdf

(e) Motion Under Gravity

659. A tennis ball is dropped on to the floor from a height of 9.8 m. It rebounds to a height 5.0 m. Ball comes in contact with the floor for 0.2 s The average acceleration during contact is ---- ms^{-2} (Given g = 10 ms^{-2})

JEE Main-29.01.2023, Shift-I

Ans. (120) : According to question,



$$v = \sqrt{2gh} = \sqrt{2\times10\times9.8} = 14\,m/s$$

After collision ball rebound to height 5 m

$0 = v_1^2 - 2\times g\times5$

$v_1 = \sqrt{2\times g\times5} = \sqrt{2\times10\times5} = 10\,m/s$

Average acceleration,

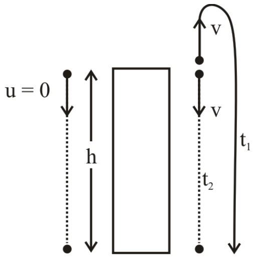
$$= \frac{v_1-(-v)}{t} = \frac{10+14}{0.2} = \frac{24}{0.2} = 120\,m/s^2$$

660. A ball when thrown upward from a tower with a given velocity takes time t_1 to reach the ground. The same ball when thrown downward with same velocity from the tower takes time t_2 to reach the ground. If the ball is dropped freely from the same tower, the time taken to reach the ground will be

(a) $t_1 - t_2$
(b) $\frac{t_1+t_2}{2}$
(c) $\sqrt{t_1\times t_2}$
(d) $\sqrt{t_1^2-t_2^2}$

SCRA-2015
Kerala CEE 2005
BITSAT- 2009-2015

Ans. (c) :



For case I^{st},

$$-h = vt_1 - \frac{1}{2}gt_1^2$$

$$+\frac{h}{t_1} = -v + \frac{1}{2}gt_1 \;\ldots\ldots\; (i)$$

For case II^{nd},

$$-h = -vt_2 - \frac{1}{2}gt_2^2$$

$$\frac{h}{t_2} = v + \frac{1}{2}gt_2 \;\ldots\ldots\; (ii)$$

Adding equation (i) and equation (ii), we get

$$\frac{h}{t_1} + \frac{h}{t_2} = \frac{1}{2}gt_1 + \frac{1}{2}gt_2$$

$$h\left(\frac{1}{t_1}+\frac{1}{t_2}\right) = \frac{g}{2}(t_1+t_2) \Rightarrow h\frac{(t_1+t_2)}{t_1.t_2} = \frac{g}{2}(t_1+t_2)$$

$$h = \frac{g\,t_1\,t_2}{2} \;\ldots\ldots\; (iii)$$

For case III^{rd},

$u = 0,\ t = ?$

$$-h = 0\times t - \frac{1}{2}gt^2 \Rightarrow h = \frac{1}{2}gt^2$$

$$t^2 = \frac{2}{g}\times h \qquad \ldots.(iv)$$

Putting the value of h from equation (iii) in equation (iv) we get-

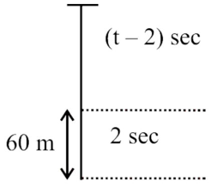
$$t^2 = \frac{2}{g}\times\frac{g\,t_1.t_2}{2} \Rightarrow t = \sqrt{t_1.t_2}$$

661. A body dropped from top of a tower fall through 60 m during the last two seconds of its fall. The height of tower is : (g = 10 m/s^2)

(a) 95 m
(b) 60 m
(c) 80 m
(d) 90 m

UPSEE - 2005
CG PET- 2005
AIPMT-1991

Ans. (c) : Let the total time be t



Initial velocity (u) = 0

After (t – 2) sec, final velocity

$v = 0 + g\times(t-2)$

$v = g(t-2)$

Now 60 m height covered with velocity v in 2 sec–

$$\therefore\ 60 = g(t-2)\times2 + \frac{1}{2}\times g(2)^2$$

$$60 = 20(t-2) + \frac{1}{2}\times10\times4$$

$t = 4$ sec

Hence, total height $= \frac{1}{2}gt^2$

$$= \frac{1}{2}\times10\times16$$

$= 80$ m

@apna_pdf

662. The ratio of distance traversed in successive intervals of time when a body falls freely under gravity from certain height is

(a) 1 : 2 : 3 (b) 1 : 5 : 9

(c) 1 : 3 : 5 (d) $\sqrt{1}:\sqrt{2}:\sqrt{3}$

(e) 1 : 4 : 9

Kerala CEE- 2014, 2005

Ans. (c) : (i) Distance travelled in 1 sec,

$s_1 = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times(1)^2$

$s_1 = 5m$

(ii) Distance travelled in 2 sec

$s_2 = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times(2)^2$.

$s_2 = 20m$

(iii) Distance travelled in 3 sec

$s_3 = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times(3)^2$

$s_3 = 45m$

The ratio of distance,

$s_1 : s_2 : s_3 = 5 : (20 - 5) : (45 - 20)$

$= 5 : 15 : 25$

$= 1 : 3 : 5$

663. A stone is thrown vertically upwards. When the stone is at a height equal to half of its maximum height its speed will be 10 m/s, then the maximum height attained by the stone is (Take g = 10 m/s^2)

(a) 3 m (b) 15 m

(c) 1 m (d) 10 m

JCECE-2014
AIIMS-1999

Ans. (d) : When the stone is at a height equal to half of its maximum height

$v = 10$ m/s

From, $v^2 = u^2 - 2gh$

$(10)^2 = u^2 - 2\times 10\times\frac{h}{2}$

$100 = u^2 - 10h$ ....(i)

Speed at the maximum height,

$v = 0$

$v^2 = u^2 - 2gh$

$0 = u^2 - 2\times 10\times h$

$u^2 = 20h$ ....(ii)

From equation (i) and (ii), we get–

$100 = 20h - 10h$

$10h = 100 \Rightarrow h = 10m$

664. A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball at $\frac{T}{3}$ second

(a) $\frac{8h}{9}$ meters from the ground

(b) $\frac{7h}{9}$ meters from the ground

(c) $\frac{h}{9}$ meters from the ground

(d) $\frac{17h}{18}$ meters from the ground

AIIMS-2012, 2000
AIEEE 2004

Ans. (a) : Given,

Height of tower = h

Time taken to reach the ground = T

From,

$h = ut + \frac{1}{2}gt^2$

$h = 0 + \frac{1}{2}gT^2$..........(i)

Distance travelled in T/3 second

$h = \frac{1}{2}g\left(\frac{T}{3}\right)^2 = \frac{1}{2}g\frac{T^2}{9}$

$= \frac{h}{9}$ [from eq^n (i)]

$\therefore$ Distance of ball from the ground $= h - \frac{h}{9} = \frac{8h}{9}$

665. A balloon going upward with a velocity of 12m/s is at a height of 65 m from the earth's surface at any instant. Exactly at this instant a ball drops from it. How much time will the ball take in reaching the surface of earth? (g = 10 m/s^2)

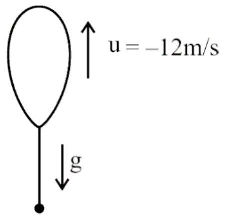
(a) 5 s (b) 6 s

(c) 7 s (c) 8 s

AIIMS-2017
UPSEE - 2005

Ans. (a) : Given

$$\left.\begin{array}{l} u = -12m/s \\ g = 10m/s^2 \\ h = 65m \end{array}\right. \left\{\begin{array}{l} \text{Upwared direction}(-ve) \\ \text{Downward direction}(+ve) \end{array}\right\}$$



From second equation of motion–

$h = ut + \frac{1}{2}gt^2$

$65 = -12\times t + \frac{1}{2}\times 10t^2$

@apna_pdf

or $\quad 5t^2 - 12t - 65 = 0$

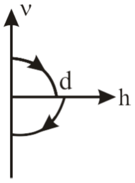
$5t^2 - 25t + 13t - 65 = 0$

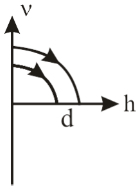
$5t(t-5) + 13(t-5) = 0$

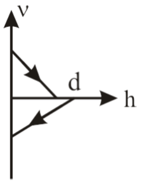
$(t-5)(5t+13) = 0$

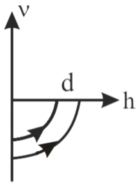
$\therefore \quad t = 5$ sec.

666. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height $\frac{d}{2}$. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground as

(a)


(b)


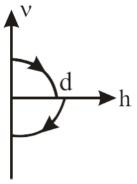
(c)


(d)


AMU-2017, 2013
IIT JEE-2000

Ans. (a) : The equation $v^2 - u^2 = 2gh$ gives velocity of the ball at a height h during its downward journey as

$$\vec{v}_{down} = -\sqrt{2g(d-h)}$$



This velocity remains negative till the ball strikes the ground. At bouncing from the ground the ball rises to a height d/2.

Thus the speed of the ball during upward motion at a height h is

$$\vec{v}_{up} = -\sqrt{gd - 2gh} \quad \text{(Less Negative)}$$

Which is positive and becomes zero at h = d/2.

667. A ball is dropped from a high rise platform at t = 0 starting from rest. After 6 seconds another ball is thrown downwards from the same platform with a speed v. The two balls meet at t = 18s. What is the value of v? (take g = 10 m/s^2)

(a) 75 m/s (b) 55 m/s
(c) 40 m/s (d) 60 m/s

AIIMS-27.05.2018(M)
AIPMI-2010

Ans. (a) : Distance travelled by first ball 18s is equal to the distance travelled by second ball in 12 s

For Ist ball

$$h = ut + \frac{1}{2}gt^2 \qquad (\because u = 0)$$

$$h = 0 + \frac{1}{2}\times 10 \times (18)^2$$

$$h = 1620\text{m}$$

For 2nd ball

$$h = ut + \frac{1}{2}gt^2 \qquad (\because u = v)$$

$$1620 = v \times 12 + \frac{1}{2}\times 10 \times (12)^2$$

$$v = \frac{1620 - 720}{12} = 75\text{m/s}$$

668. A balloon of mass M descends with an acceleration a (where a < g). What mass need to be removed from the balloon, so that it starts ascending with acceleration, *a*?

(a) $\frac{2M}{(a+g)}$ (b) $\frac{2Ma}{(a+g)}$

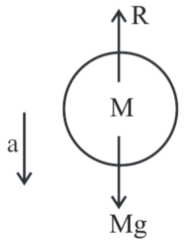
(c) $\frac{2Ma}{(a-g)}$ (d) $\frac{2Ma}{(g-a)}$

AP EAMCET (18.09.2020) Shift-II
AIPMT- 2014

Ans. (b) : Let m' be the mass remove from M i.e. mass of balloon to around balloon by a,

Let R be the resistance by air,

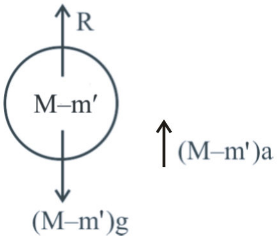
Balloon Descending



$$R + Ma = Mg$$

$$R = M(g-a)$$

Balloon Ascending



$$R = (M - m')g + (M - m')a$$

$$R = (Mg - m'g) + Ma - m'a$$

$$M(g-a) = Mg - m'g + Ma - m'a$$

$$Mg - Ma = Mg - m'g + Ma - m'a$$

$$= ma - m'(g + a) + Ma$$

$$\therefore \quad m'(g+a) = 2Ma$$

$$\therefore \quad m' = \frac{2Ma}{g+a}$$

@apna_pdf

669. A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height h. Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and coming down respectively.

(a) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$ (b) $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

(c) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (d) $\frac{1}{3}$

JEE Main-29.07.2022, Shift-I
JEE Main 27/07/2021 Shift-I

Ans. (b) : We know that,

Projected speed of ball (u) = $\sqrt{2gh}$

According to question, when ball is moving upward

$$s = \frac{h}{3}, \quad a = -g$$

Using Newton's second Law of motion –

$$s = ut + \frac{1}{2}at^2$$

$$\frac{h}{3} = \sqrt{2gh}\,t + \frac{1}{2}(-g)t^2$$

$$t^2\left(\frac{g}{2}\right) - \sqrt{2gh}\ t + \frac{h}{3} = 0$$

From quadratic equation,

$$t_1, t_2 = \frac{\sqrt{2gh} \pm \sqrt{2gh - 4 \times \frac{g}{2} \times \frac{h}{3}}}{g}$$

So, the ratio of two different times of the ball reaching h/3 is

$$\frac{t_1}{t_2} = \frac{\sqrt{2gh} - \sqrt{\frac{4gh}{3}}}{\sqrt{2gh} + \sqrt{\frac{4gh}{3}}} = \frac{\sqrt{6}-\sqrt{4}}{\sqrt{6}+\sqrt{4}} = \frac{\sqrt{2}\left[\sqrt{3}-\sqrt{2}\right]}{\sqrt{2}\left[\sqrt{3}+\sqrt{2}\right]}$$

$$\frac{t_1}{t_2} = \frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$$

670. A ball is released from a height h. If t_1 and t_2 be the required time to complete first half and second half of the distance respectively. Then, choose the correct relation between t_1 and t_2.

(a) $t_1 = \left(\sqrt{2}\right)t_2$ (b) $t_1 = \left(\sqrt{2}-1\right)t_2$

(c) $t_2 = \left(\sqrt{2}+1\right)t_1$ (d) $t_2 = \left(\sqrt{2}-1\right)t_1$

JEE Main-29.07.2022, Shift-II

Ans. (d) : Initially, u = 0 and for height h

Using the equation of motion-

$$s = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}g(t_1 + t_2)^2$$

$$\frac{2h}{g} = (t_1 + t_2)^2 \text{-----------(i)}$$

And for height h/2,

$$\frac{h}{2} = \frac{1}{2}gt_1^2$$

$$t_1 = \sqrt{\frac{h}{g}} \text{----------(ii)}$$

From equation (i) and (ii), we get –

$$\sqrt{\frac{2h}{g}} = t_1 + t_2$$

$$t_2 = \sqrt{\frac{2h}{g}} - \sqrt{\frac{h}{g}} \Rightarrow t_2 = \sqrt{\frac{h}{g}}\,(\sqrt{2}-1)$$

$$t_2 = (\sqrt{2}-1)t_1$$

671. A juggler throws balls vertically upwards with same initial velocity in air. When the first ball reaches its highest position, he throws the next ball. Assuming the juggler throws n balls per second, the maximum height the balls can reach is

(a) g/2n (b) g/n

(c) 2gn (d) $g/2n^2$

JEE Main-29.07.2022, Shift-II

Ans. (d) : According to the question, juggler throws n balls each second.

$\therefore \quad t = \frac{1}{n}$ sec

At highest point, v = 0

Using, v = u + at,

$$0 = u + (-g)\frac{1}{n}$$

$$u = \frac{g}{n} \text{----------(1)}$$

Now, $v^2 = u^2 + 2as$

$$0 - \left(\frac{g}{n}\right)^2 = 2(-g)h$$

$$\frac{-g^2}{n^2} = -2gh \Rightarrow \frac{g}{2n^2} = h$$

672. When a ball is dropped into a lake from a height 4.9 m above the water level, it hits the water with a velocity v and then sinks to the bottom with the constant velocity v. It reaches the bottom of the lake 4.0 s after it is dropped. The approximate depth of the lake is :

(a) 19.6 m (b) 29.4 m

(c) 39.2 m (d) 73.5 m

JEE Main-27.06.2022, Shift-II

Ans. (b) : Given data, h = 4.9 m

$\because \quad v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 9.8 \times 4.9 \qquad (\because u = 0)$

$v = 9.8$ m/s

$\because \quad s = ut + \frac{1}{2}at^2$

@apna_pdf

$$4.9 = 0 + \frac{1}{2}(9.8)t^2$$

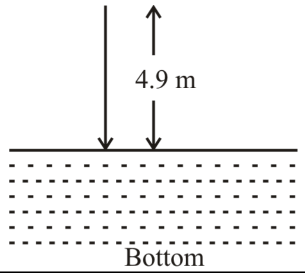
$t = 1$ sec

So, the ball travels in the lake for $t = 3$ sec

Depth = distance travelled in 3 sec

Depth = 9.8 × 3

Depth = 29.4 m



673. A ball is thrown upward from the top of a building at an angle of 30^0 to the horizontal and with an initial speed of 20 m s^{-1}. If the ball strikes the ground after 3s, then the height of the buildings is–
(acceleration due to gravity = 10 ms^{-2})

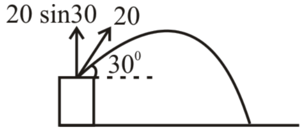
(a) 10 m (b) 15 m
(c) 20 m (d) 25 m

AP EAMCET-07.07.2022, Shift-II

Ans. (b) : Given data,

$u = 20$ m/s , $\theta = 30^o$

$t = 3$ sec



So, according to question,

When the ball is thrown upward

$$s = ut - \frac{1}{2}gt^2$$

$$s = 20\sin30^o \times 3 - \frac{1}{2}\times10\times3^2$$

$$s = 30 - 45$$

$\therefore$ $s = -15$ m ⇒ -+-s = 15 m

674. When a ball is dropped from a height h it takes t sec to reach the ground. If the same experiment is done on a different planet having the mass 100 times the earth's mass and radius 10 times the earth's radius, then the time it will take to cover the same height in the new planet is

(a) t s (b) 100 ts
(c) $\frac{t}{100}$s (d) $\frac{t}{10}$s

AP EAMCET-05.07.2022, Shift-II

Ans. (a) : If a ball is dropped from a height h it takes t sec to reach the ground

So, $u = 0$, distance travelled = h

$\because$ $s = ut + \frac{1}{2}at^2$

Put the given value,

$$h = 0 + \frac{1}{2}gt^2 \qquad (\because a = g \text{ at earth})$$

$$h = \frac{1}{2}gt^2 \qquad \text{..... (i)}$$

Now for different planet having,

M = 100 Me (given)

R = 10 Re (given)

So to calculate gravitational acceleration on that planet,

We know

$$g = \frac{GM}{R^2}$$

$$\therefore \quad g' = \frac{G(100\,Me)}{(10\,Re)^2}$$

$$g' = \frac{100GM_e}{100R_e^2} = \frac{GM}{R^2} = g$$

We can say that g' for another planet is as same as g.

Hence, if ball takes t' second on other planet

$$s = ut' + \frac{1}{2}g't'^2 \Rightarrow h' = 0 + \frac{1}{2}g't'^2$$

To cover same distance means

$h = h'$

Hence,

$$\frac{1}{2}gt^2 = \frac{1}{2}gt'^2 \Rightarrow t' = t \text{ sec}$$

675. A ball of mass 0.5 kg is dropped from the height of 10m. The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is —— —— m. [Uge g = $10m/s^2$]

JEE Main-26.06.2022, Shift-I

Ans. (5) : Given that,

Mass of the ball, (M) = 0.5 kg and height (h) = 10m

initial velocity (u) = 0 m/s

$$s = ut + \frac{1}{2}at^2 \qquad \text{....(i)}$$

Magnitude of velocity = Magnitude of the acceleration due to gravity

$gt = g \Rightarrow t = 1$ sec.

From equation (i)

$s = 0 + (1/2) \times 10 \times (1)^2 = 5$m

Height at which velocity and acceleration due to gravity becomes the same is –

$H - s = 10 - 5 = 5$m

676. From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5s. A third ball released, from the rest from the same location, will reach the ground is _____s.

JEE Main-24.06.2022, Shift-I

@apna_pdf

Ans. (3) : $s = ut + \frac{1}{2}at^2$

Ball throw vertically upward

$$h = u \times 6 - \frac{1}{2}g(6)^2$$

$$h = 6u - 18g \quad \text{....(i)}$$

and

Ball throw vertically downward

$$h = u(1.5) + \frac{1}{2}g(1.5)^2$$

$$h = u(1.5) + \frac{2.25g}{2} \quad \text{....(ii)}$$

Multiplying equation (ii) by 4 we get

$$4h = 6u + 4.5\,g \quad \text{....(iii)}$$

From equation (i) and equation (iii), we get,

$$-3h = -22.5\,g$$

$$h = 7.5\,g \quad \text{....(iv)}$$

We know,

$$h = \frac{1}{2}gt^2 \qquad (u=0) \quad \text{....(v)}$$

Using equation (iv) and equation(v)

$$7.5g = \frac{1}{2}gt^2 \Rightarrow 7.5 \times 2 = t^2$$

$$t^2 = 15 \Rightarrow t = 3.87 \approx 3\text{sec}$$

677. An object of mass 5kg is thrown vertically upwards from the ground. The air resistance produces a constant retarding force of 10N throughout the motion. The ratio of time of ascent to the time of descent will be equal to : [Use g= 10ms^{-2}]

(a) 1 :1
(b) $\sqrt{2}:\sqrt{3}$
(c) $\sqrt{3}:\sqrt{2}$
(d) 2:3

JEE Main-24.06.2022, Shift-II

Ans. (b) : For upward motion acceleration = g + a

for downward motion acceleration = g – a

$$h = ut + \frac{1}{2}at_a^{\ 2}$$

$$= 0 + \frac{1}{2}(g+a)t_a^{\ 2} \quad \text{....(i)}$$

Then $h = 0 + \frac{1}{2}(g-a)t_d^{\ 2}$ ....(ii)

$$f = ma$$

$$a = f/m = \frac{10}{5} = 2\text{m/s}^2$$

Equation (i) divided by equation (ii)

$$\frac{t_a}{t_d} = \sqrt{\frac{g-a}{g+a}} \Rightarrow \frac{t_a}{t_d} = \sqrt{\frac{10-2}{10+2}} = \sqrt{\frac{8}{12}}$$

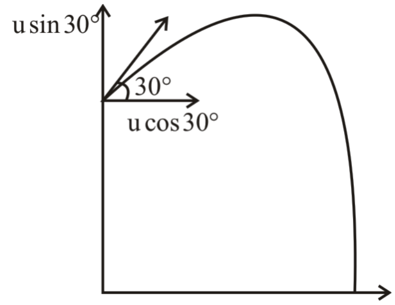
$$\frac{t_a}{t_d} = \sqrt{\frac{2}{3}}$$

678. A ball is thrown upward from the top of a building at angle of 30^0 to the horizontal with an initial speed of 15 ms^{-1}. If the ball hits the ground after 3s, then the height of building is– (acceleration due to gravity = 10 ms^{-2})

(a) 30m
(b) 12.5m
(c) 25.5m
(d) 22.5m

AP EAMCET-08.07.2022, Shift-I

Ans. (d) : We know



$$u_1 = 15\sin 30° = \frac{15}{2}\text{m/s},$$

$$a = -g = -10\text{m/s}^2$$

$$t = 3\text{s}$$

Then, from second equation of motion

$$|h| = \left|u_1 t + \frac{1}{2}at^2\right|$$

$$|h| = \left|\frac{15}{2} \times 3 - \frac{1}{2} \times 10 \times (3)^2\right|$$

$$|h| = |-22.5|$$

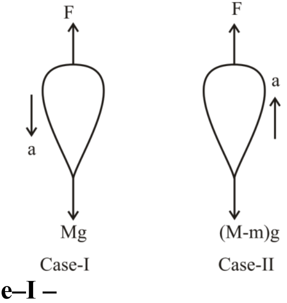
$$h = 22.5\text{m}$$

679. A hot air balloon is descending with a constant acceleration of 2 ms^{-2}. The mass of the balloon and its contents is 600 kg. Assuming the volume of balloon is kept constant the mass of the balloon required so that the balloon starts ascending with the same acceleration. (Acceleration due to gravity = 10 m s^{-2})

(a) 400 kg
(b) 200 kg
(c) 100 kg
(d) 500 kg

AP EAMCET-12.07.2022, Shift-I

Ans. (a) : Let m kg mass is removed



In case–I –

The equation of motion of the balloon.

$$Mg - F = Ma \quad \text{........(i)}$$

In case – II –

The equation of motion of the balloon

$$F-(M-m)g = (M-m)a$$

$$F - Mg + mg = Ma - ma \quad \text{......... (ii)}$$

Adding equation (i) and (ii) we get

$$mg = 2Ma - ma$$

$$m(g+a) = 2Ma$$

@apna_pdf

$$m = \frac{2Ma}{(g+a)} \Rightarrow m = \frac{2\times600\times2}{(10+2)}$$

= 200 kg

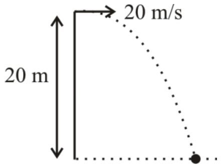
Thus, required mass = 600–200 = 400 kg

680. A ball is thrown horizontally at a speed of 20 m s^{-1}, from a height of 20 m above the ground. The magnitude of its velocity as it strikes the ground is
(Acceleration due to gravity = 10 m s^{-2})

(a) 28.3 m s^{-1} (b) 20 m s^{-1}
(c) 40 m s^{-1} (d) 32.6 m s^{-1}

AP EAMCET-12.07.2022, Shift-I

Ans. (a): ∵ $v_x = 20$ m/sec
$u_y = 0$ m/sec



$$\because \quad s_y = u_y t - \frac{1}{2}gt^2 \quad (\because \text{ball is droping down})$$

$$-20 = 0\times t - \frac{1}{2}\times10\times t^2$$

t = 2 sec

∵ Horizontal velocity remains same at every point.

∴ $v_x = 20$ m/s

Now, $v_y = u_y - gt$

$v_y = 0 - 10 \times 2$

$v_y = -20$ m/sec

$$\because \quad v = \sqrt{v_x^2 + v_y^2}$$

$$= \sqrt{20^2 + (-20)^2} = 20\sqrt{2}$$

= 28.28 = 28.3 m/sec

681. A boy drops a ball from the top of a building consisting of several floors. Each floor has the same height. The ball covers one floor from the top in one second. The number of floors, the ball will cover in three seconds is

(a) 4 (b) 9
(c) 6 (d) 5

TS EAMCET 30.07.2022, Shift-II

Ans. (b) : Let the height of each floor be h.

Now, for t = 1s

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 \times 1 + \frac{1}{2}\times10\times(1)^2$$

h = 5 m

The height of each floor is 5m

Then, for t = 3 s

$$s_h = ut + \frac{1}{2}gt^2$$

$$s_h = (0)\times3 + \frac{1}{2}\times10\times(3)^2$$

$s_h = 45$ m

We know that height of each floor is 5m

So,

$$\text{No. of floors} = \frac{45}{5} = 9$$

682. Two balls A and B are placed at the top of 180 m tall tower. Ball A is released from the top at t = 0 s. Ball B is thrown vertically down with an initial velocity 'u'at t = 2 s. After a certain time, both balls meet 100 m above the ground. Find the value of 'u' in ms^{-1} [use g = 10 ms^{-2}]

(a) 10 (b) 15 (c) 20 (d) 30

JEE Main-29.06.2022, Shift-I

Ans. (d) : Given data, tower height (h) = 180 m

Distance covered by ball (s) = 180 – 100 = 80 m

$$\text{Time (t)} = \sqrt{\frac{2h}{g}}$$

$$t = \sqrt{\frac{2\times80}{10}}$$

t = 4 sec

Time taken by ball B to meet A = 2 sec

$$\text{Now,} \quad s = ut + \frac{1}{2}at^2$$

$$80 = u \times 2 + \frac{1}{2}(10)(2)^2$$

80 = 2u + 20

60 = 2u

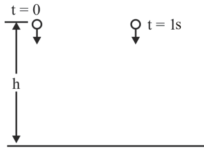
u = 30 m/s

683. A ball is dropped from rest at time t =0 from certain height A. Second ball is dropped from same height at time t = l s. At what time t, the distance between two balls becomes 10 m?

(a) 1.25 s (b) 1.5 s
(c) 1.75 s (d) 2 s

TS EAMCET 06.08.2021, Shift-II

Ans. (b) :



$$h_1 = \frac{1}{2}gt^2 \qquad \text{.....(i)}$$

$$h_2 = \frac{1}{2}g(t-1)^2 \quad \text{......(ii)}$$

From equation (i) & (ii)

$$h_1 - h_2 = 10\text{m}$$

$$\frac{1}{2}gt^2 - \frac{1}{2}(g)(t-1)^2 = 10 \Rightarrow \frac{1}{2}g\left[t^2 - (t-1)^2\right] = 10$$

$$5t^2 - 5(t-1)^2 = 10 \qquad [\because g = 10\text{m/s}^2]$$

or 5(2t – 1)= 10

2t = 3

$$\boxed{t = 1.5\text{sec}}$$

@apna_pdf

684. A stone falls freely under gravity. It covers distance d_1 and d_2 in the first 4 second, and the next 8 seconds respectively. The ratio $\frac{d_2}{d_1}$ is

(a) 8 (b) 2
(c) 16 (d) 12

TS EAMCET 04.08.2021, Shift-II

Ans. (a) : A stone falls freely under gravity,

$u_1 = 0 \quad t = 4$ sec

It revers distance d_1 & d_2 in first 4 second and the next 8 second respectively.

$$\therefore \quad d_1 = u_1t_1 + \frac{1}{2}gt_1{}^2$$

$$= 0 \times 4 + \frac{1}{2}\times g\times(4)^2 = \frac{1}{2}\times g\times 16$$

$$d_1 = 8g$$

Now,

$$u_2 = u_1 + gt = 0 + 4g$$

$$\boxed{u_2 = 4g}$$

and $d_2 = u_2t_2 + \frac{1}{2}gt_2{}^2$

$$\therefore \quad d_2 = 4gt_2 + \frac{1}{2}gt_2^2$$

at $t_2 = 8$ sec.

$$d_2 = 4g \times 8 + \frac{1}{2}g\times 8^2 = 4g\times 8 + \frac{1}{2}g\times 64$$

$$= 32g + 32g = 64g$$

$$d_2 = 64g$$

Then ratio, $\frac{d_2}{d_1} = \frac{64g}{8g} = 8$

$$\boxed{\frac{d_2}{d_1} = 8}$$

685. A ball is projected upwards. Its acceleration at the highest point is ——

(a) zero
(b) directed upwards
(c) directed downwards
(d) such as cannot be predicted

AP EAMCET-19.08.2021, Shift-II

Ans. (c) : Acceleration of the ball during any stage is constant in magnitude and direction.
It is $g = 9.8$ m/s^2
and its downwards.

686. A rocket lifts off from ground and accelerate upwards at 1 m/s^2. 20 seconds after lift off a piece breaks off from the bottom of rocket. After breaking off, how much time it takes approximately to reach the ground? (Take g = 10 m/s^2)

(a) 6.3 s (b) 4.5 s
(c) 10.5 s (d) 8.5 s

TS EAMCET 05.08.2021, Shift-I

Ans. (d): Let x_1 high attained by the rocket with acceleration 1m/sec^2 at time (t) = 20 seconds.
By Newton's second law–

$$x_1 = ut + \frac{1}{2}at^2$$

$$= 0\times t + \frac{1}{2}\times 1\times(20)^2$$

$$= 200 \text{ m.}$$

Velocity of rocket in 20 second.

$$v_1 = u + at = 0 + 1 \times 20$$

$$v_{max} = 20\text{m/sec.}$$

Now, for height x_2

$$v_2^2 = v_1^2 - 2gx_2$$

Where, v_2 = velocity at maximum height = 0

v_1 = 20 m/sec.

$$\therefore \quad x_2 = \frac{v_1^2}{2g} = \frac{20\times 20}{2\times 10}$$

$$= 20 \text{ meter.}$$

During maximum height, rocket forwards earth due to gravity.
This at height x_1

$$-200 = 20t - \frac{1}{2}gt^2$$

$$-200 = 20t - \frac{1}{2}\times 10t^2$$

$$\Rightarrow 5t^2 - 20t - 200 = 0$$

$$\Rightarrow t^2 - 4t - 40 = 0$$

Solving for t and neglecting negative sign

$$t = \frac{4+\sqrt{166}}{2} = 8.44\text{sec.}$$

That after breaking off time taken by racket to come out to earth

$$= 8.44 \text{ sec.}$$

687. Two balls are released from the same position at a height of 500 m above ground, one after the other, with an interval of 1s. What is the distance between the two balls when the first hits ground? (Acceleration due to gravity g = 10 m/s^2)

(a) 95 m (b) 65 m
(c) 130 m (d) 175 m

TS EAMCET 05.08.2021, Shift-II

Ans. (a) : Let, h_1 = 500 m, u = 0
From 2nd equation of motion-

$$h_1 = ut_1 + \frac{1}{2}gt^2{}_1$$

$$500 = 0 + \frac{1}{2}\times 10\times t^2{}_1$$

$$500 = 5t_1{}^2$$

$$t_1^2 = 100$$

$$t_1 = 10 \text{ sec}$$

@apna_pdf

$\because$ Time interval between two balls is 1

Then, $t_2 = (10-1) = 9$ sec

$$h_2 = ut_2 + \frac{1}{2}gt_2^2$$

$$h_2 = \frac{1}{2}gt_2^2$$

$$h_2 = \frac{1}{2}\times 10\times 9^2$$

$h_2 = 5 \times 81$

$h_2 = 405$ m

$\therefore$ Distance between two balls $= h_1 - h_2$

$= 500 - 405$

$= 95$ m

688. A ball thrown upwards vertically reaches a height 25 m in 1 s. The ratio of total distance covered by the ball in time t = 2 s and t = 4 s is (use g = 10 m/s^2)

(a) 1
(b) $\frac{4}{5}$
(c) $\frac{2}{3}$
(d) $\frac{3}{4}$

TS EAMCET 06.08.2021, Shift-I

Ans. (b) : Let initial velocity is u.

$$\therefore\ h = ut - \frac{1}{2}gt^2$$

$$25 = u\times 1 - \frac{1}{2}\times 10\times 1^2$$

$25 = u - 5$

$u = 30$ m/s

Max. height that ball can attain

$v^2 = u^2 - 2g\,H$

At maximum height, v = 0

$0 = (30)^2 - 2\times 10\times H$

$20H = 900$

$$H = \frac{900}{20} = 45\text{m}$$

Max time to reach the highest point

$v = u - gt$

$0 = 30 - 10t$

$t = 3$ Sec

Distance covered in 2 sec

$$s_{t=2} = 30\times 2 - \frac{1}{2}\times 10\times 2^2 = 60 - 20$$

$s_{t=2} = 40$ m

Distance covered in 4 second = Distance in 3 second + distance in 1 second,

$$s_{t=4} = H + ut + \frac{1}{2}gt^2$$

$$s_{t=4} = 45 + 0\times t + \frac{1}{2}\times 10\times 1^2$$

$s_{t=4} = 45 + 5$

$s_{t=4} = 50$m

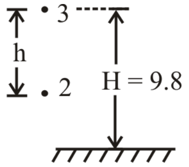
$$\text{Ratio} = \frac{s_{t=2}}{s_{t=4}} = \frac{40}{50} = \frac{4}{5}$$

689. Water drops are falling from a nozzle of a shower onto the floor, from a height of 9.8 m. The drops fall at a regular interval of time. When the first drop strikes the floor, at that instant, the third drop begins to fall. Locate the position of second drop from the floor when the first drop strikes the floor.

(a) 4.18 m
(b) 2.94 m
(c) 2.45 m
(d) 7.35 m

JEE Main-27.08.2021, Shift-II

Ans. (d) : From figure



$$H = \frac{1}{2}gt^2$$

$$9.8 = \frac{1}{2}\times 9.8\times t^2 \Rightarrow t = \sqrt{2}\text{ sec}$$

And if Δt = time interval between drops.

Then,

$$h = \frac{1}{2}g\,(\sqrt{2}-\Delta t)^2 \Rightarrow 0 = \frac{1}{2}g(\sqrt{2}-\Delta t)^2$$

$$\left(\sqrt{2}-\Delta t\right)^2 = 0 \Rightarrow \sqrt{2} - 2\Delta t = 0$$

or $$\Delta t = \frac{1}{\sqrt{2}}$$

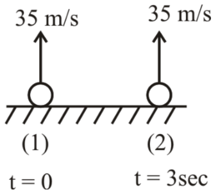
$$\therefore\quad h = \frac{1}{2}g\left(\sqrt{2} - \frac{1}{\sqrt{2}}\right)^2 \Rightarrow h = 2.45$$

So, $H - h = 9.8 - 2.45 = 7.35$m

690. Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3s with the same initial velocity of 35 m/s, then these balls collide at a height of .... m. (Take, g =10m/s^2)

JEE Main-26.08.2021, Shift-I

Ans. (50) :



From the given question,

When the balls Collide,

$Y_1 = Y_2$

$$35t - \frac{1}{2}\times 10\times t^2 = 35\,(t-3) - \frac{1}{2}\times 10\times (t-3)^2$$

on solving, $0 = -150 + 30t$

$t = 5$ sec

@apna_pdf

So, height at which balls will collide is,

$$H = 35t - \frac{1}{2} \times 10 \times t^2$$

$$H = 35 \times 5 - \frac{1}{2} \times 10 \times (5)^2$$

$$H = 50 \text{ m}$$

691. A balloon was moving upwards with a uniform velocity of 10 m/s. An object of finite mass is dropped from the balloon when it was at a height of 75 m from the ground level. The height of the balloon from the ground when object strikes the ground was around, is (Take, the value of g = 10 m/s^2)

(a) 300 m (b) 200 m
(c) 125 m (d) 250 m

JEE Main-25.07.2021, Shift-II

Ans. (c) : Given data,

$u = 10$ m/s
$s = -75$m
$H = ?$

$\because$ We know that,

$$s = ut + \frac{1}{2}at^2$$

$$-75 = 10t + \frac{1}{2}(-10) \times t^2$$

$t^2 - 2t - 15 = 0$
$t^2 - 5t + 3t - 15 = 0$
$(t-5)(t+3) = 0$
$t = 5$ sec, $t \neq -3$

$\therefore$ Height of balloon from the ground,

$H = 75 + 10 \times 5$
$H = 125$ m

692. A ball is thrown at 30° with horizontal from the top of roof 20m high with a speed of 13m.s^{-1}. At what distance from the throwing point will the ball, once again be at a height of 20 m from the ground? (g = 10m.s^{-2})

(a) 10.2 m (b) 14.6 m
(c) 18.6 m (d) 9.8 m

AP EAMCET-25.08.2021, Shift-I

Ans. (b) : Given data,

$\theta = 30^\circ$
$u = 13$ m/s
$g = 10$ m/s^2
$R = ?$

$$\therefore\ R = \frac{u^2 \sin(2\theta)}{g} = \frac{(13)^2 \sin(2\times30^\circ)}{10}$$

$$= \frac{169 \times \sin 60^\circ}{10}$$

$R = 14.6$ m

693. A metal ball falls from a height of 32 m onto a steel plate. If the coefficient of restitution is 0.5. The height to which the ball will rise after second bounce is _____

(a) 4 m (b) 2 m
(c) 8 m (d) 16 m

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (b) : $h_n = h.e^{2n}$

n= number of bounce, h= Initial height

$h_2 = 32 \times (0.5)^{2\times2}$

$$= 32 \times \frac{1}{16}$$

$= 2$ m

694. A hammer is dropped into a mine. Its velocities at depths d, 2d and 3d are in the ratio

(a) 1 : 2 : 3 (b) $1 : \sqrt{2} : \sqrt{3}$
(c) 1 : 4 : 9 (d) 6 : 3 : 2
(e) 1 : 1 : 1

Kerala CEE 2021

Ans. (b) : $s_1 = d$, $s_2 = 2d$, $s_3 = 3d$

Newton's law of motion

$v^2 = u^2 + 2gs \qquad \{u=0\}$

$v_1^2 = 2gs_1$

$v_2^2 = 2gs_2$

$v_3^2 = 2gs_3$

$v_1 = \sqrt{2gs_1}$

$v_1 = \sqrt{2g.d} \qquad$ ....(i)

$v_2 = \sqrt{2g2d} \qquad$ ....(ii)

$v_3 = \sqrt{2g3d} \qquad$ ....(iii)

Dividing equation (i), (ii), and (iii) we get

$v_1 : v_2 : v_3 = 1 : \sqrt{2} : \sqrt{3}$

695. From a 200 m high tower, one ball is thrown upwards with speed of 10 ms^{-1} and another is thrown vertically downwards at the same speeds simultaneously. The time difference of their reaching the ground will be nearest to

(a) 12 s (b) 6 s
(c) 2 s (d) 1 s

BITSAT-2020

Ans. (c) : When ball is thrown upward with a velocity of 10 m/s.

Initial velocity (u) = 10 m/s

When ball will reach at the highest point velocity is zero.

Final velocity (v) = 0

From first equation of motion,

$v = u - gt$
$0 = 10 - 10 \times t$
$t = 1$ sec

The ball thrown upward will have zero velocity in 1 second. It returns back to thrown point in another 1second with the same velocity as the second ball. The time difference between the two balls in reaching the ground will be 2 second.

@apna_pdf

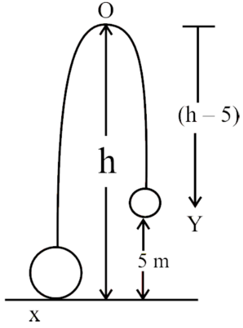
696. A ball is thrown straight upward from ground with a speed of 20 m/s. The ball was caught on its way down at a point 5 m above the ground. The time taken by the ball during entire trip is (assume, g = 10 m/s^2)

(a) $2+\sqrt{3}$ s (b) $3-\sqrt{3}$ s

(c) $2+\sqrt{2}$ s (d) 3.5 s

TS-EAMCET.14.09.2020, Shift-2

Ans. (a) : According to question



If the ball is thrown upward let it covered distance h from the ground

Total distance = h

Distance at which it caught = h – 5

If time taken from x to O is t_1 and from O to Y is t_2 then

Total time = $t_1 + t_2$

$$v = u - gt_1$$
$$0 = 20 - 10t_1$$
$$t_1 = 2 \text{ sec}$$

When ball travelled from x to O it covered distance h

Thus, $h = ut - \frac{1}{2}gt^2$

$$h = 20\times 2 - \frac{1}{2}\times 10\times (2)^2$$
$$h = 20 \text{ m}$$

When ball travelled from O to Y

Thus, $(h-5) = 0\times t_2 + \frac{1}{2}gt_2^2$

$$(20-5) = 0 + \frac{1}{2}\times 10\times t_2^2$$
$$15 = 5t_2^2$$
$$t_2^2 = \frac{15}{5} = 3$$
$$t_2 = \sqrt{3}$$

Hence total time covered = $t_1 + t_2$

$$= \left(2+\sqrt{3}\right))\text{sec}$$

697. A ball of mass 100 g is dropped at time *t* = 0. A second ball of mass 200 g is dropped from the same point at *t* = 0.2 s. The distance between the centre of mass of two balls and the release point at t = 0.4 s is (Assume, g = 10 m/s^2)

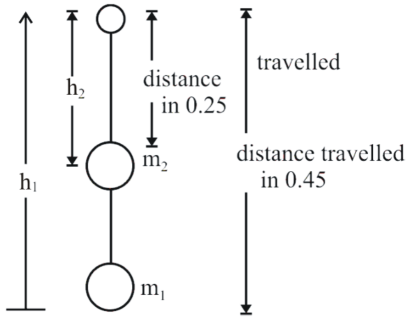
(a) 0.4 m (b) 0.5 m

(c) 0.6 m (d) 0.8 m

TS-EAMCET-09.09.2020, Shift-1

Ans. (a) : Given as,

m_1 = 100 g m_2 = 200 g



The second ball is only travelled for 0.2 sec because it dropped after 0.2 sec.

First ball travelled for 0.4 sec

Distance travelled by first ball = h_1, time = 0.4 sec

$$h_1 = ut + \frac{1}{2}gt^2$$
$$h_1 = 0 + \frac{1}{2}\times 10\times (0.4)^2$$
$$h_1 = 0.8\text{m}$$

Distance travelled by second ball = h_2, time 0.2 sec

$$h_2 = ut + \frac{1}{2}gt^2$$
$$= 0 + \frac{1}{2}\times 10\times (0.2)^2 = 0.2 \text{ m}$$

Distance between centre of mass is given by

$$M_{cm} = \frac{m_1h_1 + m_2h_2}{m_1 + m_2}$$
$$= \frac{100\times 0.8 + 200\times 0.2}{100+200} = \frac{120}{300}$$
$$M_{cm} = 0.4 \text{ m}$$

698. A ball is dropped from a height H from rest. The ball travels $\frac{H}{2}$ in last 1.0s. The total time taken by the ball to hit the ground is

(a) 3.85 s (b) 3.41 s

(c) 2.55 s (d) 4.65 s

TS-EAMCET-09.09.2020, Shift-1

Ans. (b) : Given that,

Height = H

Ball travels $\frac{H}{2}$ in 1 s

if total time taken by the ball is t sec then it should take (t – 1) sec to cover left $H - \frac{H}{2} = \frac{H}{2}$ distance.

So, from Newton's equation

$$H = ut + \frac{1}{2}gt^2$$
$$H = 0 + \frac{1}{2}gt^2$$
$$H = \frac{1}{2}gt^2 \quad \ldots(i)$$

@apna_pdf

For $\frac{H}{2}$ height it takes (t – 1) sec.

$$\frac{H}{2} = 0 + \frac{1}{2}g(t-1)^2$$

$$\frac{H}{2} = \frac{1}{2}g(t-1)^2$$

$$H = g(t-1)^2 \qquad \ldots(ii)$$

On dividing equation (i) to equation (ii) we get,

$$\frac{H}{H} = \frac{\frac{1}{2}gt^2}{g(t-1)^2}$$

$$g(t-1)^2 = \frac{1}{2}gt^2$$

$$2(t-1)^2 = t^2$$

$$2(t^2+1-2t) = t^2$$

$$2t^2+2-4t = t^2$$

$$t^2-4t+2 = 0$$

$$t = \frac{4\pm\sqrt{16-8}}{2} = \frac{4\pm\sqrt{8}}{2}$$

$$t = \frac{4\pm2\sqrt{2}}{2}$$

$$t = 2+\sqrt{2} \quad \text{or} \quad 2-\sqrt{2}$$

So $t = 2 + 1.41$

$t = 3.41$ sec

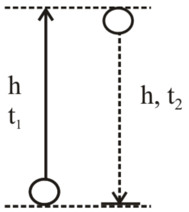
699. A body is projected vertically upwards. The time corresponding to height h while ascending and while descending are t_1 and t_2 respectively. Then the velocity of projection is (g is acceleration due to gravity)

(a) $\frac{g\sqrt{t_1t_2}}{2}$ (b) $\frac{g(t_1+t_2)}{2}$

(c) $g\sqrt{t_1t_2}$ (d) $\frac{gt_1t_2}{t_1+t_2}$

COMEDK 2020

Ans. (b) :



Given that,

s = h, a = –g because the acceleration due to gravity in downward direction

$$h = ut_1 + \frac{1}{2}(-g)t_1^2$$

$$h = ut_1 - \frac{1}{2}gt_1^2$$

$$gt_1^2 - 2ut_1 + 2h = 0$$

$$t_1 = \frac{2u\pm\sqrt{(-2u)^2-4\times g\times2h}}{2g}$$

$$t_1 = \frac{2u\pm\sqrt{4u^2-8gh}}{2g} \Rightarrow t_1 = \frac{2u\pm2\sqrt{u^2-2gh}}{2g}$$

$$t_1 = \frac{u\pm\sqrt{u^2-2gh}}{g}$$

for ascending

$$t_1 = \frac{u-\sqrt{u^2-2gh}}{g} \qquad \ldots(i)$$

for descending

$$t_2 = \frac{u+\sqrt{u^2-2gh}}{g} \qquad \ldots(ii)$$

From equation (i) & (ii)

$$t_1+t_2 = \frac{u-\sqrt{u^2-2gh}}{g} + \frac{u+\sqrt{u^2-2gh}}{g}$$

$$t_1+t_2 = \frac{2u}{g} \Rightarrow u = \frac{(t_1+t_2)g}{2}$$

700. A ball of mass 200 g is thrown directly upward from X-axis from x = 2 m position. The initial speed of the ball is 40 m/s. The magnitude (absolute value) of the angular momentum of the ball about the origin (x = 0), when ball is halfway back to the ground is:

(a) 8 N.m (b) 16 N.m

(c) $8\sqrt{2}$ N.m (d) $16\sqrt{2}$ N.m

TS EAMCET 28.09.2020, Shift-II

Ans. (c) : Given,mass of ball (m)= 200 gm = 0.2 kg

Initial velocity of ball = 40 m/sec.

Distance from origin (R) = 2

Using equation of motion

$$v^2 = u^2 - 2gh$$

$$0 = (40)^2 - 2\times10\,h$$

$$20\,h = 1600 \Rightarrow h = 80$$

On return journey : let v_0 be velocity at half way

By using equation of motion

$$v^2 = u^2 + 2gh$$

$$v_0^2 = 0+2\times10\times40 = 20\sqrt{2}$$

Angular momentum about P will be

$$L = mvR = 0.2\times20\sqrt{2}\times2 = 8\sqrt{2}\text{ N.m}$$

701. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to (Here, g is the acceleration due to gravity).

(a) $t = \frac{2}{3}\sqrt{\frac{h}{g}}$ (b) $t = 1.8\sqrt{\frac{h}{g}}$

(c) $t = \sqrt{\frac{2h}{3g}}$ (d) $t = 3.4\sqrt{\frac{h}{g}}$

JEE Main-05.09.2020, Shift-I

@apna_pdf

Ans. (d) : From given question,

$$t_0 = \sqrt{\frac{2h}{g}}$$

$$\therefore \quad v_0 = \sqrt{\frac{2h}{g}} \times g = \sqrt{2gh}$$

Let, t_1 = time to reach top = $\frac{v_0}{g} = \frac{\sqrt{2gh}}{g} = \sqrt{\frac{2h}{g}}$

$$\therefore \quad H = h + h = 2h$$

Now, $t_2 = \text{time of fall} = \sqrt{\frac{2\times(2h)}{g}} = 2\sqrt{\frac{h}{g}}$

$\therefore$ Total time = $t_1 + t_2 = \sqrt{\frac{2h}{g}} + 2\sqrt{\frac{h}{g}}$

$$\text{Total time} = \left(2+\sqrt{2}\right).\sqrt{\frac{h}{g}}$$

$$\text{Total time} = 3.4\sqrt{\frac{h}{g}}$$

702. A ball is dropped from a bridge that is 45 m above the water. It falls directly into a boat which is moving with constant velocity. The boat is 12 m away from the point of impact when the ball is dropped. The speed of the boat is (take, $g = 10\ m/s^2$)

(a) 2 m/s (b) 3 m/s
(c) 4 m/s (d) 5 m/s

TS-EAMCET-09.09.2020, Shift-1

Ans. (c) : The time taken by the ball to fall into the moving boat using kinematic equation,

$$s = ut + \frac{1}{2}gt^2$$

Since, the ball is dropped from that height, we can see the ball has zero initial velocity.

$$s = 0\times t + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2s}{g}}$$

Given, $s = 45$ m, $g = 10\ m/s^2$

$$t = \sqrt{\frac{2\times 45}{10}} = \sqrt{9} \Rightarrow t = 3s$$

Hence, Speed of boat is-

$$v = \frac{d}{t}$$

$$v = \frac{12m}{3s} \Rightarrow v = 4\ m/s$$

703. A man in a lift ascending with an acceleration throws a ball vertically up with a velocity v and catches it after time 3 sec. Afterwards when the lift is descending with the same acceleration, the man again throws the ball vertically up with the same velocity and catches it after 1 sec. Find v (use g = 10 m/s).

(a) 7.5 m/s (b) 9.0 m/s
(c) 10.5 m/s (d) 12.5 m/s

TS EAMCET 29.09.2020, Shift-II

Ans. (a) : Given,

$t_1 = 3$ sec, $t_2 = 1$ sec
$v = ?$, $g = 10\ m/s^2$

We know that,

$$t_1 = \frac{2v}{g+a} \text{ and } t_2 = \frac{2v}{g-a}$$

$$g + a = \frac{2v}{t_1} \qquad \ldots.(i)$$

$$g - a = \frac{2v}{t_2} \qquad \ldots(ii)$$

From eq. (i) and (ii)

$$2g = \frac{2v}{t_1} + \frac{2v}{t_2} \Rightarrow g = v\left(\frac{1}{t_1}+\frac{1}{t_2}\right)$$

$$v = g \times \frac{1}{\left(\frac{1}{t_1}+\frac{1}{t_2}\right)}$$

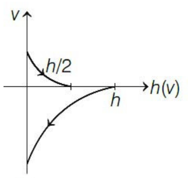
or $$v = g\frac{t_1.t_2}{t_1+t_2}$$

$$v = 10\times\frac{(3\times1)}{3+1} = 10\times\frac{3}{4} = \frac{3\times5}{2}$$

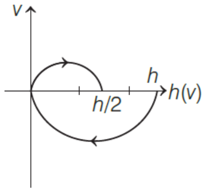
v = 7.5 m/sec

704. A tennis ball is released from a height h and after freely falling on a wooden floor, it rebounds and reaches height h /2. The velocity versus height of the ball during its motion may be represented graphically by (Graphs are drawn schematically and on not to scale)

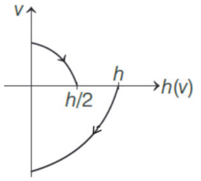
(a)



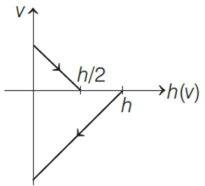
(b)



(c)



(d)



JEE Main-04.09.2020, Shift-I

Ans. (c) : $v^2 = u^2 + 2gh$ (u = 0)

i.e., $v^2 \propto h$ (non-linear)

i.e., Parabola

Downward velocity is negative and upward velocity is positive. After collision, it reverse its direction with lesser magnitude.

705. A ball is thrown vertically downward with a velocity of 20 m/s from the top of a tower. It hits the ground after some time with a velocity of 80 m/s. The height of the tower is ($g = 10\ m/s^2$)

@apna_pdf

(a) 340 m (b) 320 m
(c) 300 m (d) 260 m

[NEET (Sep.) 2020]

Ans. (c) : Let the height of the tower is h.
The motion of the ball is constant accelerating motion with acceleration $g = 10\ m/s^2$

$u = 20\ m/s$
$v = 80\ m/s$

According to equation of motion for constant accelerating motion
(Here downward direction is negative and upward direction is positive)

$$v^2 - u^2 = 2(-g)(-h)$$
$$v^2 - u^2 = 2gh$$
$$(80)^2 - (20)^2 = 2 \times 10 \times h$$
$$h = \frac{6000}{20}$$
$$h = 300\ m$$

706. A stone thrown vertically upwards with an initial velocity 'v' from the top of a tower reaches the ground with velocity 3v. The height of tower is

(a) $3v^2/g$ (b) $4v^2/g$
(c) $6v^2/g$ (d) $9v^2/g$

MHT-CET 2020

Ans. (b) : Given, Initial velocity = v, u = 3v
Now,

$$v^2 = u^2 - 2gh$$
$$v^2 = (3v)^2 - 2gh$$
$$v^2 - 9v^2 = -2gh$$
$$2gh = 8v^2$$
$$h = \frac{4v^2}{g}$$

707. A stone falls freely such that the distance covered by it in the last second of its motion is equal to the distance covered by it in the first 5s. It is in air for ....s.

(a) 12 (b) 13
(c) 25 (d) 26

AP EAMCET (21.09.2020) Shift-I

Ans. (b): Since, stone falls freely, hence its initial velocity, u = 0
Distance covered by the stone in first 5s, is given as

$$h_1 = ut + \frac{1}{2}gt^2$$
$$= 0 \times 5 + \frac{1}{2} \times 9.8 \times 5^2$$
$$= 122.5$$

Since, distance travelled in last second (t^{th} second) is equal to distance travelled in first 5s, hence

$$h_1 = u + \frac{1}{2}g(2t-1)$$
$$122.5 = 0 + \frac{1}{2} \times 9.8\,(2t-1)$$
$$2t - 1 = \frac{122.5 \times 2}{9.8}$$
$$2t - 1 = 25 \Rightarrow 2t = 25 + 1$$
$$2t = 26 \Rightarrow t = 13\ sec$$

708. Acceleration due to gravity

(a) Increases with altitude
(b) Decreases with altitude
(c) Is independent of altitude
(d) First decreases and then increases with altitude

AP EAMCET (17.09.2020) Shift-I

Ans. (b) : Acceleration due to gravity decreases with altitude. The value of g is inversely proportional to the distance from the centre of the earth.

709. Assertion : When a body is dropped or thrown upward from the same height, it would reach the ground at the same time.
Reason : Direction of projection does not affect the time of flight.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-26.05.2019(E) Shift-2

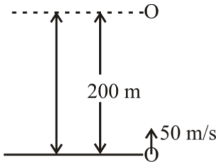
Ans. (a) : If both assertion and reason are true and reason is the correct explanation of assertion.

710. A ball is allowed to free fall from the top of a 200 m tall tower. Simultaneously another ball is through vertically upwards at a velocity 50 m/s. The balls will meet at a height of

(a) 121.6 m from ground
(b) 125.3 from ground
(c) 132.1 m from ground
(d) None of above

Assam CEE-2019

Ans. (a) :



The height travelled by dropped ball

$$200 - h = \frac{1}{2}gt^2 \quad ....(i)$$

The height travelled by ball thrown vertically upward

$$h = 50\,t - 0.5 \times g \times t^2 \quad ....(ii)$$

Adding equation (i) and (ii)

$$200 = 50t$$
$$t = 4\ sec.$$

Substituting the value in equation (i)

$$200 - h = \frac{1}{2} \times 9.81 \times 4^2$$

h = 121.6 m, from the ground

@apna_pdf

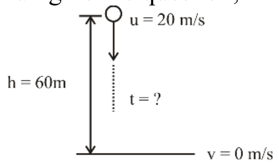
711. A stone is thrown from the top of a building with an initial downward velocity of 20 m/s. The top of the building is 60 m above the ground. Calculate the time taken (in seconds) by the stone to hit the ground. (Given g = 10 m/s^2)

(a) 2 (b) 3

(c) 4 (d) 5

AMU-2019

Ans. (a) : According to the question,



$\because \quad v = u - gt$

$u = gt$

$$t = \frac{u}{g} = \frac{20}{10} = 2\,\text{sec}.$$

712. A gun and a target are at the same horizontal level separated by a distance of 600 m. The bullet is fired from the gun with a velocity of 500 ms^{-1}. In order to hit the target, the gun should be aimed to a height h above the target. The value of h is

(Acceleration due to gravity, *g* = 10 ms^{-2})

(a) 2.4 m (b) 3.6 m

(c) 7.2 m (d) 10.8 m

AP EAMCET (20.04.2019) Shift-1

Ans. (c): Given that,

Distance between gun and target = 600m

Velocity of bullet = 500 ms^{-1}

Distance = velocity of bullet × time

$$t = \frac{600}{500} = \frac{6}{5} = 1.2\,\text{sec}$$

From second equation of the motion,

$$h = ut + \frac{1}{2}gt^2$$

Putting the given values, we get

$$h = 0 \times (1.2) + \frac{1}{2} \times (-10) \times (1.2)^2$$

$$h = \frac{1}{2} \times (-10) \times (1.2 \times 1.2) \Rightarrow h = -7.2\text{ m}$$

$$|h| = 7.2\,\text{m}$$

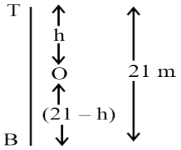
713. Ball-1 is dropped from the top of a building from rest. At the same moment, ball-2 is thrown upward towards ball-1 with a speed 14 m/s from a point 21 m below the top of building. How far will the ball-1 have dropped when it passes ball-2. (Assume, acceleration due to gravity, g = 10 m/s^2.)

(a) $\frac{45}{4}$m (b) $\frac{52}{6}$m

(c) $\frac{37}{2}$m (d) $\frac{25}{2}$m

TS-EAMCET-03.05.2019, Shift-1

Ans. (a) : Let the ball from the top of the building dropped and covered a distance h so the distance covered by the ball thrown from the ground is (21 – h) and they meet at a point O in time t.



Distance travelled when ball dropped from top T

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \Rightarrow h = \frac{1}{2} \times 10 \times t^2$$

$h = 5t^2$ …(i)

Distance travelled by the ball thrown upward

$21 - h = ut - \frac{1}{2}gt^2$ (g = –ve for upward direction)

$21 - 5t^2 = 14t - 5t^2$

{∵ from eqn (i)}

$5t^2 - 5t^2 = 14t - 21$

$14t = 21$

$$t = \frac{21}{14} = \frac{3}{2} \Rightarrow t = 1.5$$

Putting the value of 't' in equation (i)

We get,

$$h = 5t^2 = 5 \times \left(\frac{3}{2}\right)^2 = \frac{45}{4}\text{m}$$

714. A ball is thrown vertically upward from the ground at time, t = 0 s. It passes the top of a tower at t = 3 s and 2 s later it reaches and its maximum height. The height of the tower is (Acceleration due to gravity, g = 10 m/s^2)

(a) 105 m (b) 125 m

(c) 85 m (d) 65 m

TS-EAMCET-06.05.2019, Shift-1

Ans. (a) : Given,

The ball reaches at top of a tower at the time,

$t_1 = 3$ sec

Reaches at the maximum height at time,

$t_2 = 2$ sec

$\therefore \quad t = t_1 + t_2$

$t = 3 + 2$

$t = 5$ sec

According to the first equation of motion,

$v = u - gt$

$0 = u - 10 \times 5$ {∵ g = 10 m/s^2}

$u = 50$ m/s

If h is the height of tower, the from the second equation of motion,

$$h = ut - \frac{1}{2} \times gt^2 = 50\times3 - \frac{1}{2}\times10\times3^2$$

$$= 150 - 45 = 105\text{ m.}$$

@apna_pdf

715. A ball is projected vertically up from ground. Boy A standing at the window of first floor of a nearly building observes that the time interval between the ball crossing him while going up and the ball crossing him while going down is 2s. Another boy B standing on the second floor notices that time interval between the ball passing him twice, during up motion and down motion is 1s. Calculate the difference between the vertical positions of boy B and boy A (Assume, acceleration due to gravity, $g = 10\ m/s^2$)

(a) 8.45 m (b) 3.75 m
(c) 4.25 m (d) 2.50 m

TS-EAMCET-03.05.2019, Shift-2

Ans. (b) : Boy A standing on first floor observe that the ball takes 2s to cross him upward and downward .

That means ball takes 1 sec to reach its maximum height

At maximum height v = 0, t = 1 sec

Let initial velocity $= u_A$

Thus, using first equation of motion v = u – gt

$0 = u_A - (10) \times 1$

$u_A = 10\ m/s$

If the ball takes 1 sec to cross boy B at second floor and reach him again

So, ball take 0.5 sec to reach from A to B

Thus, using second equation of motion

$$s = ut - \frac{1}{2}at^2 \quad (\because t = 0.5\sec)$$

$$= u_A t - \frac{1}{2}at^2 = 10\times0.5 - \frac{1}{2}\times10\times(0.5)^2$$

= 3.75 m

716. A hot air balloon is rising upward with acceleration $2.5\ m/s^2$. The ratio of air density outside the balloon to that inside will be (Assume $g = 10\ m/s^2$, Neglect the mass of balloon fabric)

(a) $\frac{3}{2}$ (b) $\frac{5}{4}$
(c) $\frac{4}{3}$ (d) $\frac{5}{3}$

TS EAMCET 08.05.2019, Shift-I

Ans. (b) : We know, that downward force acting on body is mg and upward force acting on body is $F_b = f_{out}$ vg.

According to Newton's second law,

$$\rho_{out} Vg - \rho_{in} Vg = \rho_{in} Va$$

$$\left(\frac{\rho_{out}}{\rho_{in}} - 1\right)g = a$$

$$\frac{\rho_{out}}{\rho_{in}} = \frac{2.5}{10} + 1$$

$$\frac{\rho_{out}}{\rho_{in}} = \frac{1}{4} + 1$$

$$\frac{\rho_{out}}{\rho_{in}} = \frac{5}{4}$$

717. A particle is thrown vertically up with a velocity of $100\ m\ s^{-1}$. What will be the time taken by the body to reach the ground? Assume g= 10 N.

(a) 5 s (b) 10 s
(c) 15 s (d) 20 s

J&K-CET-2019

Ans. (d) : Given,

$$u = 100\ m/s$$

$$g = -10\ m/s^2$$

From first equation of motion, we get -

$$v = u + gt$$

$$0 = 100 + (-10)t$$

$$10t = 100$$

$$t = 10 \text{ second}$$

Therefore, the approximate time taken to reach the ground is 10 s + 10s = 20s.

718. A ball is dropped from top of a tower of 100m height. Simultaneously another ball was thrown upward from bottom of the tower with a speed of 50 m/s. They will cross each other after ($g = 10\ m/s^2$)

(a) 1 s (b) 2 s
(c) 3 s (d) 4 s

Manipal UGET-2019

Ans. (b) : Suppose they will cross each other after time t then the sum of the value of their displacement should equal to height of tower.

∴ Distance covered by first ball –

$$h_1 = \frac{1}{2}gt^2$$

And distance covered by second ball

$$h_2 = ut - \frac{1}{2}gt^2 \ (u = 50 m/s)$$

Given that,

$h_1 + h_2 = 100$, u = 50 m/s

$$\frac{1}{2}gt^2 + ut - \frac{1}{2}gt^2 = 100$$

ut = 100

50 × t = 100

t = 2 sec.

719. A stone is dropped from a height of 100 m, while another one is projected vertically upwards from the ground with a velocity of 25 m/s at the same time.

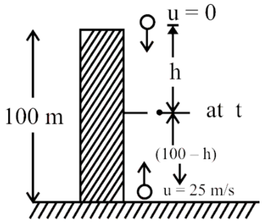
The time in seconds after which they will have the same height is (acceleration due to gravity, $g = 10\ ms^{-2}$)

(a) 4 (b) 5
(c) 6 (d) 7

TS-EAMCET-05.05.2018, Shift-1

Ans. (a) : If the stones meet after t second then distance travelled by first stone is h in time t and distance travelled by the second stone = 100 – h in time t.

@apna_pdf



For first stone–

Distance travelled, $h = ut + \frac{1}{2}gt^2$

$$h = 0 + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \qquad \ldots(i)$$

For second stone

Distance travelled,

$$100 - h = ut - \frac{1}{2}gt^2$$

$$100 - h = 25t - \frac{1}{2}gt^2 \text{ --------(ii)}$$

Put the value of $\frac{1}{2}gt^2$ from equation (i) in equation (ii), we get–

$$100 - h = 25t - h$$

$$100 = 25t$$

$$t = 4 \text{ sec}$$

720. A girl throws a stone horizontally from the roof of a house 12 m above the ground with a speed of 15 m/s. Neglecting air resistance the time it takes for the stone to reach the ground is

(a) 1.55 sec (b) 3.1 sec

(c) 2.34 sec (d) 4.10 sec

TS EAMCET 02.05.2018, Shift-II

Ans. (a) : Let u_v be the vertical component of velocity of projection of stone.

We know the stone is thrown horizontally but vertical component acts.

$$h = ut + \frac{1}{2}gt^2$$

$$12 = 0 + \frac{1}{2} \times g \times t^2 \qquad [\therefore u_v = 0]$$

$$t^2 = \frac{12 \times 2}{9.8}$$

$$t^2 = 2.44$$

$$t = 1.55 \text{ second}$$

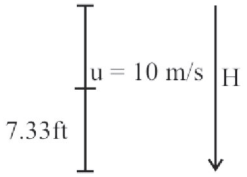
721. A man of height 7.33 ft releases a stone from the slingshot just above his head. If the stone travels in a vertical direction towards the sky with velocity of 10 ms^{-1}, then the time it takes to reach the ground is (Assume acceleration due to gravity g = 10 ms^{-2})

(a) 1.6s (b) 1.8s

(c) 2.0s (d) 2.2s

TS EAMCET (Medical)-02.05.2018, Shift-I

Ans. (d) :



Let the stone goes at height h from heat of the man

$$\therefore \quad v^2 = u^2 - 2gh$$

$$o = (10)^2 - 2 \times 10 \times h$$

$$20h = 100$$

$$h = 5m$$

$$\because \quad v = u - gt$$

$$0 = 10 - 10 \times t$$

$$10t = 10$$

$$t = 1 \text{ sec}$$

Total height of stone from ground

$$H = 5m + 7.33ft$$

$$= 5m + 2.23m = 7.23m$$

Now,

$$\because \quad s = ut + \frac{1}{2}gt^2$$

$$7.23 = 0 + \frac{1}{2} \times 10 \times 1^2$$

$$t^2 = \frac{7.23 \times 2}{10} = 1.44$$

$$t = 1.2 \text{ sec}$$

So, total time taken by stone to reach ground

$$= 1 + 1.2 = 2.2 \text{ sec}$$

722. A body is projected horizontally form the top of a tall tower with a velocity of 30 ms^{-1}. At time t_1, its horizontal and vertical components of the velocity are equal and time t_2, its horizontal and vertical displacements are equal. Then $t_2 - t_1$ is (take, g = 10 ms^{-2})

(a) 1 s (b) 1.5 s

(c) 2 s (d) 3 s

AP EAMCET (23.04.2018) Shift-2

Ans. (d): Given, $v_x = 30$m/s, $\quad v_x = v_y$

As per first conditions, at t_1,

$$v_y = 0 + g\,t_1$$

$$30 = 10t_1$$

$$t_1 = 3 \text{ s}$$

As per second conditions,

at t_2, $\quad s_x = s_y$

$$s_x = 30t_2 \qquad \text{....(i)}$$

$$s_y = \frac{1}{2} \times 10 \times t_2^2 \qquad \text{....(ii)}$$

Equation (i) and (ii),

$$30t_2 = \frac{1}{2} \times 10t_2^2$$

$$t_2 = 6 \text{ s}$$

$$t_2 - t_1 = 6 - 3$$

$$t_2 - t_1 = 3 \text{ s}$$

@apna_pdf

723. A ball is thrown upwards with a speed u from a height h above the ground. The time taken by the ball to hit the ground is

(a) $\sqrt{2h/g}$ (b) $\sqrt{8h/g}$

(c) $\dfrac{\sqrt{u^2/2gh}}{g}$ (d) $\dfrac{u}{g}+\sqrt{\dfrac{2h}{g}}$

JIPMER-2018

Ans. (d) : Let, t_1 = time taken by ball for upward

$$a=\frac{v-u}{t}\Rightarrow -g=\frac{0-u}{t_1}\Rightarrow t_1=\frac{u}{g}\text{ --------(i)}$$

t_2 = Time taken by the ball to return

$$h = ut_2 + \frac{1}{2}at_2^2$$

$$h = 0\times t_2 + \frac{1}{2}gt_2^2\ [a = g]$$

$$t_2=\sqrt{\frac{2h}{g}}$$

$\because$ Total time (t) = $t_1 + t_2$

$$t=\frac{u}{g}+\sqrt{\frac{2h}{g}}$$

724. Two bodies falling freely under gravity from heights 'h' and 'H' cover displacements of $\frac{5h}{9}$ and $\frac{11h}{9}$ respectively during last second of their motion. If acceleration due to gravity is 10 ms^{-2}, then H is

(a) 45 m (b) 90 m

(c) 180 m (d) 360 m

AP EAMCET-25.04.2018, Shift-II

Ans. (c) : From first body-

$$h=\frac{1}{2}gt_1^2 \qquad \text{....(i)}$$

$$t_1=\sqrt{\frac{2h}{g}}$$

For second body -

$$H=\frac{1}{2}gt_2^2 \qquad \text{....(ii)}$$

$$t_2=\sqrt{2\frac{H}{g}}$$

Distance travelled in last second journey –

$$s_1=h-\frac{1}{2}g(t_1-1)^2 \qquad \text{....(iii)}$$

$$s_2=H-\frac{1}{2}g(t_2-1)^2 \qquad \text{....(iv)}$$

For first body, from equation (iii) $s_1=\frac{5h}{9}$

$$\frac{5h}{9}=h-\frac{1}{2}g(t_1-1)^2$$

$$\frac{1}{2}g(t_1-1)^2=\frac{4h}{9}=\frac{4}{9}\times\frac{1}{2}gt_1^2$$

$$t_1=3\text{sec.}$$

From question (i)

$$h=\frac{1}{2}g(3)^2=5\times9=45\text{m}$$

Now, from equation (iv)

$$\frac{11h}{9}=H-\frac{1}{2}g(t_2-1)^2$$

$$\frac{11\times45}{9}=H-\frac{1}{2}g(t_2-1)^2$$

$$55=\frac{1}{2}gt_2^2-\frac{1}{2}g(t_2-1)^2\Rightarrow 55=5[2t_2-1]$$

$$t_2=6\text{sec.}$$

$$H=\frac{1}{2}gt_2^2=\frac{1}{2}\times10\times36=180\text{m}$$

725. The water drops fall at regular intervals from tap 5 m above the ground. The third drop is leaving the tap at an instant when the first drop touches the ground. How far above the ground is the second drop at that instant? (Take g = 10 m/s^2)

(a) 1.25 m (b) 2.50 m

(c) 3.75 m (d) 5.00 m

AIIMS-26.05.2018(E)

Ans. (c) : Given

Height of tap, h = 5m, g = 10 m/s^2

For I^{st} drop,

$$h = ut + \frac{1}{2}gt^2 \qquad (\because u = 0)$$

$$5 = 0 + \frac{1}{2}\times10\times t^2$$

$$t^2 = 1$$

$$t = 1\text{sec.}$$

So, the III^{rd} drop leaves after one second of the first drop.

$\therefore$ We can say that each drop leaves after every 0.5 sec.

Distance travelled by II^{nd} drop in 0.5 sec.

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 + \frac{1}{2}\times10\times(0.5)^2 = 1.25$$

$\therefore$ Distance of second drop from the ground

= 5 – 1.25

= 3.75m

726. Two towers A and B, each of height 20 m are situated a distance 200 m apart. A body thrown horizontally from the top of the tower A with a velocity 20 ms^{-1} towards the tower B hits the ground at point P and another body thrown horizontally from the top of tower B with a velocity 30 ms^{-1} towards the tower A hits the ground at point Q. If a car starting from rest from P reaches Q in 10 seconds, then the acceleration of the car is

(acceleration due to gravity = 10 ms^{-2})

(a) 1 ms^{-2} (b) 2 ms^{-2}

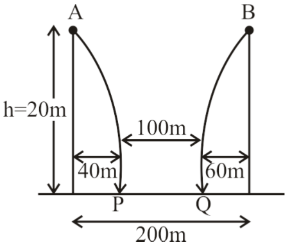
(c) 3 ms^{-2} (d) 4 ms^{-2}

AP EAMCET (23.04.2018) Shift-1

@apna_pdf

Ans. (b) : Given, height of both towers is same,

$h_1 = h_2 = h$



Time of flight, $t = \sqrt{\frac{2h}{g}}$ will be same

$$t = \sqrt{\frac{2\times20}{10}} = \sqrt{4} = 2$$

Displacement in horizontal direction from tower A to point P = $u_A t$

$= 20 \times 2 = 40$ m

Displacement in horizontal direction from tower B to point Q = $u_B t$

$30 \times 2 = 60$ m

So, distance between point P and Q

$= 200 - (40 + 60) = 100$ m

Since the distance between P and Q is covered by car in 10 s,

$\therefore$ using second equation of motion –

$$s = ut + \frac{1}{2}at^2$$

$$100 = 0\times10 + \frac{1}{2}a(10)^2$$

[$\because$ u = 0 because car starts from rest]

$$100 = \frac{1}{2}\times a\times10\times10 \Rightarrow 100 = 50a$$

$a = 2$

Thus, the acceleration of the car is $2 m/s^2$.

727. A person of mass 60 kg is inside a lift of mass 940 kg and presses the button on control panel. The lift starts moving upwards with an acceleration 1.0 m/s². If g = 10 ms⁻², the tension in the supporting cable is

(a) 8600 N (b) 9680 N

(c) 11000 N (d) 1200 N

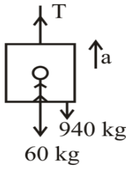
AIIMS-27.05.2018(M)

Ans. (c) : Given

Mass of person = 60 kg, Mass of lift = 940 kg.

Acceleration (a) = 1.0 m/s^2

Total mass = Mass of person + Mass of lift



= 60 + 940 = 1000 kg

The tension in the supporting cable, T = m (g + a)

= 1000 (10 + 1) = 11000 N.

728. In a vacuum, a five-rupee coin, a feather of a sparrow bird and a mango are dropped simultaneously from the same height. The time taken by them to reach the bottom is t_1, t_2 and t_3 respectively. In this situation, we will observe that

(a) $t_1 > t_2 > t_3$ (b) $t_1 > t_3 > t_2$

(c) $t_3 > t_1 > t_2$ (d) $t_1 = t_2 = t_3$

NDA (II) 2017

Ans. (d): In vacuum

g is not depends on its mass

From, $t = \sqrt{\frac{2h}{g}}$

So, $t_1 = t_2 = t_3$

If the objects are dropped from the same height they will reach the bottom simultaneously. g is the independent of the mass of the body. The acceleration due to gravity is same for acceleration object.

729. A body thrown vertical upwards with a velocity v reaches a height of 200 m. Another body B whose mass is twice that of A is thrown with a velocity 2v. Find the maximum height reached by B.

(a) 400 m (b) 800 m

(c) 100 m (d) 200 m

J&K-CET-2017

Ans. (b) : Maximum height of the particle thrown is independent of its mass and is given by

$$H_{max} = \frac{v^2}{2g} \qquad (\theta = 90^\circ)$$

For body A:-

$$200 = \frac{v^2}{2g} \qquad .....(i)$$

For body B:-

$$H = \frac{(2v)^2}{2g} \qquad (\because \text{Given, } v = 2v)$$

$$H = \frac{4v^2}{2g}$$

$$H = 4\times\frac{v^2}{2g}$$

$$H = 4\times200 \qquad \left[\because \frac{v^2}{2g} = 200\right]$$

H = 800 m

730. Water-drops are falling at regular intervals from a water-tap situated at a height of 5 meters from the ground. Just at the moment the first drop touches the ground, the third drop comes out. At the moment, the height to the second drop of water from the ground will be:

(a) 1.25 m (b) 2.50 m

(c) 3.75 m (d) 4.50 m

Assam CEE-2017

@apna_pdf

Ans. (c) : Time when first drop reach the ground = t

$$5 = \frac{1}{2} \times 10 t_1^2$$

$t_1 = 1$ sec.

As water drops fall at regular intervals from a tap therefore time difference between any two drops $\frac{1}{2}$ sec.

Then for second drop

$$H' = \frac{1}{2} \times 10 \times \left(\frac{1}{2}\right)^2 = 1.25\,\text{m}$$

Therefore distance of the second drop above the ground–

$$5 - 1.25 = 3.75 \text{ m}$$

731. A ball is dropped from the top of a tower. The distance covered in the last one second is 0.36 times the height of the tower. What is the height of the tower? ($g = 10\ m/s^2$)

(a) 125 m (b) 100 m

(c) 88 m (d) 64 m

SCRA-2015

Ans. (a) : Let the height of tower be = h

The body takes time to reach the ground = t

By second equation of motion,

$$h = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \qquad \ldots\ldots(i)$$

In the last t^{th} second, body travels 0.36 h.

Then, in $(t-1)^{th}$ seconds , it travels h – 0.36 h = 0.64 h

So, $$0.64\text{ h} = \frac{1}{2}g(t-1)^2 \qquad \ldots\ldots(ii)$$

On solving equation (i) and (ii), we get

$$\frac{h}{0.64h} = \frac{\frac{1}{2}gt^2}{\frac{1}{2}g(t-1)^2} \Rightarrow \frac{1}{0.64} = \frac{t^2}{(t-1)^2}$$

$$\frac{t}{t-1} = \frac{10}{8} \Rightarrow t = 5 \text{ second}$$

Put the value of t, in equation (i), we get -

$$h = \frac{1}{2} \times 10 \times 5^2 \Rightarrow h = 125 \text{ m}$$

732. A body of mass m is thrown up with velocity v_0. The air drag is equal to kv^2 where v is the velocity at any instant and k is a positive constant (proportionally constant). What is the velocity with which the body comes down?

(a) $\dfrac{v_0}{\left(1+\dfrac{kv_0^2}{mg}\right)}$ (b) $\dfrac{v_0}{\left(1+\dfrac{kv_0^2}{mg}\right)^{1/2}}$

(c) $\dfrac{v_0}{\left(1+\dfrac{kv_0^2}{mg}\right)^{1/3}}$ (d) None of the above

SCRA-2014

Ans. (b) : Given, mass of body = m

velocity of body = v_0

While going upward :

From Newton's second law in vertical direction,

$$m.\frac{vdv}{ds} = -\left(mg + kv^2\right)$$

$$\frac{vdv}{\left(g + \frac{kv^2}{m}\right)} = -ds$$

At the maximum height h, the speed v = 0

So,

$$\int_{v_0}^{0} \frac{vdv}{g + \left(kv^2/m\right)} = -\int_0^h ds$$

On integrating both side and after solving, we get

$$h = \frac{m}{2k}.\ln\left(1 + \frac{kv_0^2}{mg}\right) \qquad \ldots..(i)$$

When the body falls downward the net force acting on the body in downward direction equal ($mg - kv^2$), the net acceleration in downward direction, according to the Newton second law of motion

$$\frac{vdv}{ds} = g - \frac{kv^2}{m} \Rightarrow \frac{vdv}{g - \frac{kv^2}{m}} = ds$$

Thus, $$\int_0^{v'} \frac{vdv}{g - \frac{kv^2}{m}} = \int_0^h ds$$

Integrating and putting the value of h from (i), we get

$$v' = \frac{v_0}{\sqrt{1 + \frac{kv_0^2}{mg}}}$$

733. A stone of mass 0.05 kg is thrown vertically upwards. What is the direction, and magnitude of net force on the stone during its upward motion?

(a) 0.98 N vertically downwards

(b) 0.49 N vertically downwards

(c) 9.8 N vertically downwards

(d) 0.49 N vertically upwards

Karnataka CET-2015

Ans. (b) : Given,

m = 0.05 kg

Force acting on the stone (F) = mg

F = 0.05 × 9.8

F = 0.49 N

Because stone thrown vertically upward so net force acting vertically downward.

734. A person throws balls into air vertically upward in regular intervals of time of one second. The next ball is thrown when the velocity of the ball thrown earlier becomes zero. The height to which the balls rise is : (Assume, $g = 10\ ms^{-2}$)

@apna_pdf

(a) 20 m (b) 5 m
(c) 10 m (d) 7.5 m

Karnataka CET-2012

Ans. (b) : Given,

$v = 0, \quad g = 10 m/s^{-2}, t = 1 sec.$

From first equation of motion, we get-

$v = u - gt$

$0 = u - 10 \times 1$

$u = 10$ m/s

By using third equation of motion, we get

$v^2 = u^2 - 2gH$

$0 = u^2 - 2gH$

Height (H), to which the ball will rise is,

$$H = \frac{u^2}{2g}$$

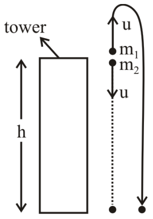
$$H = \frac{(10)^2}{2 \times 10}, \qquad H = 5 m$$

735. From the top of a tower of two stones, whose masses are in the ratio 1:2 are thrown on straight up with an initial speed u and the second straight down with the same speed u. Then, neglecting air resistance :

(a) the heavier stone hits the ground with a higher speed
(b) the lighter stone hits the ground with a higher speed
(c) both the stones will have the same speed when they hit the ground
(d) the speed can't be determined with the given data

Karnataka CET-2005

Ans. (c) : Given that,



$m_1 : m_2 = 1 : 2$

$v_1 = v_2 = \sqrt{u^2 + 2gh}$

Speed is independent of mass. So both stones will take same time and speed when they hit the ground.

736. A ball is thrown vertically upwards. Assuming the air resistance to be constant and considerable,

(a) the time of ascent ≥ the time of descent
(b) the time of ascent < the time of descent
(c) the time of ascent > the time of descent
(d) the time of ascent = the time of descent

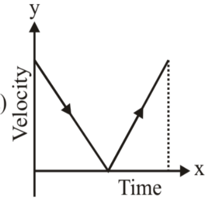
Karnataka CET-2001

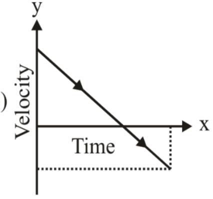
Ans. (b) : As acceleration during ascent is more than the acceleration during descent.

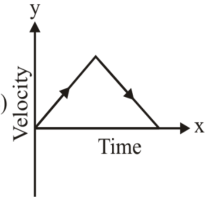
So, to cover same distance time during more acceleration will be less than with less accelerate.

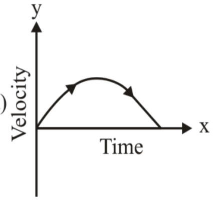
$\therefore$ the time of ascent $<$ the time of descent.

737. A particle is thrown vertically up with a certain velocity. Assuming the air resistance to be negligible, which one of the following represents the velocity (along y-axis)-time (along x-axis) graph for the entire motion of the particle till it reaches back to the ground.

(a)


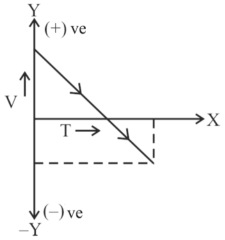
(b)


(c)


(d)


J&K CET- 2010

Ans. (b) :



During rise in positive direction velocity decrease linearly and during fall in negative direction velocity increase linearly.

Hence option (b) is correct.

738. A body is released from a great height falls freely towards the earth. Another body is released from the same height exactly a second later. Then the separation between two bodies, 2 sec after the release of the second body is nearly

(a) 15 m (b) 20 m
(c) 25 m (d) 30 m

J&K CET- 2007

Ans. (c) : Given that,

Initial velocity u = 0

Time for the first body (t_1) = 3 sec

Time for the second body (t_2) = 2 sec

The first body fall through a height s_1 during 3 sec.

$$s_1 = 0 + \frac{1}{2} g (3)^2$$

$$s_1 = 4.5 \times 9.8 m = 44.1 m$$

The second body fall through a height s_2 during 2 sec.

$$s_2 = 0 + \frac{1}{2} \times 9.8 \times 2^2$$

$$s_2 = 2 \times 9.8 = 19.6 m$$

Separation between both bodies, we get-

$s = s_1 - s_2$

$s = 44.1 - 19.6 \Rightarrow s = 24.5$ m □ 25 m

@apna_pdf

739. A ball is thrown upwards. After it has left the hand, its acceleration

(a) decreases (b) increases
(c) is constant (d) none of these

J&K CET- 1997

Ans. (c) : When the body is thrown vertically upward its acceleration remains constant. Which is equal to the acceleration due to gravity.

740. A ball released at rest from the top of a tower reaches the ground in 4 s. The height of the ball from the ground at t = 2 s of its journey is

(a) 60 m (b) 40 m (c) 20 m (d) 15 m

J&K-CET-2016

Ans. (a) : Given that,

$$t_1 = 4 \text{ sec}$$
$$u = 0$$
$$t_2 = 2 \text{sec}$$

Let h be the height of the tower

As the ball reaches the ground in 4s,

$$\therefore \quad h_1 = 0 + \frac{1}{2}gt^2$$
$$h_1 = \frac{1}{2} \times 10 \times 4^2$$
$$h_1 = 80 \text{ m}$$

The height fallen by the ball in 2s

$$h_2 = \frac{1}{2} \times 10 \times 2^2$$
$$h_2 = 20 \text{ m}$$

The height of ball from the ground

$$h' = h_1 - h_2$$
$$h' = 80 - 20$$
$$h' = 60 \text{ m}$$

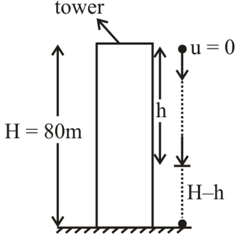
741. A ball is dropped from the top of 80 m high tower. If after 2 sec of fall the gravity (g = 10 m/s^2) disappears, then time taken to reach ground since the gravity disappeared is

(a) 2 sec (b) 3 sec
(c) 4 sec (d) 5 sec

J&K-CET-2015

Ans. (b) : Given,

Height of tower (h) = 80 m
Time (t) = 2 sec.
Initial velocity (u) = 0



So, First equation of motion–

$$v = u + gt$$
$$v = 0 + 10 \times 2$$
$$v = 20 \text{m/s}$$

Distance travelled in 2 sec

$$h = ut + \frac{1}{2}at^2$$
$$h = \frac{1}{2} \times 10 \times 2^2$$
$$h = 20 \text{m}$$

Distance to reach ground,

$$d = H - h$$
$$d = 80 - 20$$
$$d = 60 \text{ m}$$

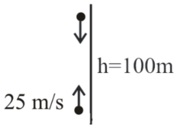
$$\text{Time,} \quad t = \frac{d}{v}$$
$$t = \frac{60}{20} = 3 \text{sec}$$

742. A ball is dropped from the top of a tower of height 100 m and at the same time another ball is projected vertically upwards from ground with a velocity 25ms^{-1}. Then, the distance from the top of the tower, at which the two balls meet is

(a) 68.4 m (b) 48.4 m
(c) 18.4 m (d) 28.4 m
(e) 78.4 m

Kerala CEE- 2014

Ans. (e) :



$$\text{Time} = \frac{\text{height}}{\text{speed}} = \frac{100}{25} = 4 \text{sec.}$$

The distance from the top of the tower, at which the two balls meet.

Now, from the second equation of motion,

$$h = ut + \frac{1}{2}gt^2$$
$$h = 0 + \frac{1}{2} \times 9.8 \times 4^2 \quad (\because u = 0)$$
$$h = 8 \times 9.8 = 78.4 \text{ m}$$

743. Two balls are dropped to the ground from different heights. One ball is dropped 2s after the other but they both strike the ground at the same time. If the first ball takes 5s to reach the ground. Then the difference in initial heights is (g = 10 ms^{-2})

(a) 20 m (b) 80 m
(c) 170 m (d) 40 m
(e) 160 m

Kerala CEE 2007

Ans. (b) : Distance travelled by first ball take 5 sec to reach the ground,

$$s_1 = \frac{1}{2}gt^2$$
$$= \frac{10}{2} \times (5)^2 = 125 \text{m}$$

@apna_pdf

Distance travelled by second ball take 3 sec to reach the ground.

$$s_2 = \frac{1}{2}gt_2^2$$

$$s_2 = \frac{10}{2}\times(3)^2 = 45\text{m}$$

Difference of initial height, we get -

$\therefore$ $s_1 - s_2 = 125 - 45$

$= 80\text{m}$

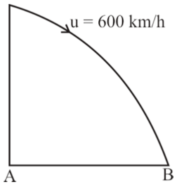
744. An aeroplane is flying horizontally with a velocity of 600 km/h and at a height of 1960 m. When it is vertically above a point A on the ground a bomb is released from it. The bomb strikes the ground at point B. The distance AB is:

(a) 1200 m (b) 0.33 km
(c) 333.3 km (d) 33 km
(e) 3.33 km

Kerala CEE 2004

Ans. (e) : Given that,

u = 600 km/h
h = 1960 m



From second equation of motion-

$$h = ut + \frac{1}{2}gt^2$$

Where, h = height of aeroplane
u = initial velocity, t = time

$\because$ Vertical velocity of the bomb is zero i.e. u = 0

$$\therefore \quad h = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2\times h}{g}} = \sqrt{\frac{2\times 1960}{9.8}} = \sqrt{400}$$

= 20 sec

Horizontal displacement of the bomb

s = AB = ut

$$s = 600 \times \frac{20}{60\times 60} \Rightarrow s = \frac{10}{3}$$

s = 3.33km

745. Two bodies of different masses are dropped from heights of 16 m and 25 m respectively. The ratio of the time taken by them to reach the ground is:

(a) $\frac{25}{16}$ (b) $\frac{5}{4}$
(c) $\frac{4}{5}$ (d) $\frac{16}{25}$
(e) $\frac{5}{8}$

Kerala CEE 2004

Ans. (c) : Given that, u = 0, g = 10m/s^2

From second equation of motion-

$$h = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2$$

$$t^2 = \frac{2h}{g}$$

or $t^2 \propto h$

$$\therefore \quad \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$$

746. A particle is thrown vertically upward with a speed of u from a tower of height H. The time taken by the particle to hit the ground is n time that taken by it to reach the highest point of its path. The relation between H, u and n is

(a) $gH = (n-2)^2u^2$ (b) $\frac{nu^2(n-2)}{2} = gH$
(c) $gH = \frac{n^2u^2}{2}$ (d) $(n-2) = \frac{gH}{u^2}$

UPSEE - 2015

Ans. (b) : Height of tower = H

Time t_1, taken to reach maximum height (v = 0) -

$$v = u + at_1$$

$$0 = u - gt_1$$

$$u = gt_1$$

$$t_1 = \frac{u}{g}\text{........(i)}$$

Let, the t_2 be the time taken to touch the ground.

$$-H = ut_2 - \frac{1}{2}gt_2^2 \text{ ....(ii)}$$

Given that,

$$t_2 = n \times t_1 = \frac{nu}{g} \qquad \text{....(iii)}$$

By the equation (i), (ii) and (iii), we get-

$$-H = u.\frac{nu}{g} - \frac{1}{2}g.\frac{n^2u^2}{g^2}$$

$$-2gH = 2nu^2 - n^2u^2$$

$$-2gH = -nu^2(n-2)$$

$$gH = \frac{nu^2(n-2)}{2}$$

747. A ball is dropped from a bridge at a height of 176.4 m over a river. After 2s, a second ball is thrown straight downwards. What should be the initial velocity of the second ball so that both hit the water simultaneously?

(a) 2.45 ms^{-1} (b) 49 ms^{-1}
(c) 14.5 ms^{-1} (d) 24.5 ms^{-1}

UPSEE - 2009

@apna_pdf

Ans. (d) : For first ball, h = 176.4m

From second equation of motion -

$$h = ut + \frac{1}{2}gt^2 \qquad (\because u = 0)$$

$$\therefore \qquad h = \frac{1}{2}gt^2$$

$$176.4 = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2 \times 176.4}{10}} = \sqrt{35.28}$$

t□ 6

For second ball, t = 6 – 2 = 4 sec.

$$h = ut + \frac{1}{2}gt^2$$

$$176.4 = u \times 4 + \frac{1}{2} \times 10 \times 4 \times 4$$

$$176.4 = 4u + 80$$

$$4u = 176.4 - 80 = 96.4$$

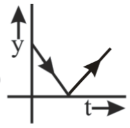
$$4u = 96.4 \qquad u = 24.1 m/s$$

$$u \approx 24.5 \text{ m/s}$$

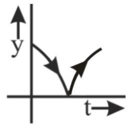
This value is approximate to 24.5 m/s

748. A ball is dropped on a floor and bounces back to a height somewhat less than the original height, which of the curves depicts its motion correctly?

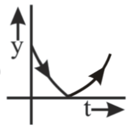
(a)



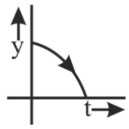
(b)



(c)



(d)



UPSEE - 2008

Ans. (b) : Let the height be y, from where the ball is dropped then

$$y = ut + \frac{1}{2}gt^2$$

$$y = 0 + \frac{1}{2}gt^2$$

$$\boxed{y = \frac{1}{2}gt^2} \qquad ....(i)$$

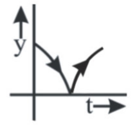
Since, the graph between y and t shows a parabola. therefore, here, y will decrease as the time increases.

Now, when the ball hit the ground and bounces back then-

From 2nd equation of motion-

$$y = ut - \frac{1}{2}gt^2 \qquad ....(ii)$$

Here, again equation (ii) forms a parabola. And here y will increase as the time increases.



Thus, here the curves given in option (b) depicts its motion correctly.

749. A stone falls freely from rest, and the distance covered by it in the last second of its motion equals the distance covered by it in the first three seconds of its motion. The stone remains in the air for

(a) 5 s (b) 8 s

(c) 10 s (d) 15 s

CG PET- 2010

Ans. (a) : Given, u = 0

Distance travelled by the stone in first 3 sec.

$$s = ut + \frac{1}{2}gt^2$$

$$s = \frac{1}{2} \times g \times (3)^2 = 4.5g$$

Distance travelled by stone in last second

$$s' = s_n - s_{n-1}$$

$$s' = \frac{1}{2}gn^2 - \frac{1}{2}g(n-1)^2$$

$$s' = \frac{1}{2}g(n^2 - n^2 - 1 + 2n)$$

$$s' = \frac{1}{2}g(2n-1)$$

Given that,

$$s' = s$$

$$\frac{1}{2}g(2n-1) = 4.5g$$

$$2n - 1 = 9$$

$$n = 5 \text{ sec}$$

750. A elevator car whose floor to distance is 2.7 m starts ascending with a constant acceleration of 1.2 m/s^2, 2s after a bolt is begin to fall from the ceiling of the car. The free fall time of the bolt is (g = 9.8m/s^2)

(a) $\sqrt{\frac{2.7}{9.8}}$s (b) $\sqrt{\frac{5.4}{9.8}}$s

(c) $\sqrt{\frac{5.4}{8.6}}$s (d) $\sqrt{\frac{5.4}{11}}$s

Manipal UGET-2013

Ans. (d) : Given,

s = 2.7 m, a = 1.2 m/s^2, t = ?

Net acceleration on the elevator car is more than acceleration due to gravity.

Since elevator car is ascending upwards, from Newton's second law, the net force is acting upwards

$\therefore$ resultant acceleration is

$$a_r = (g + a)$$

$$= (9.8 + 1.2) = 11 m/s^2$$

@apna_pdf

Relative velocity of observer to elevator is

$$u_r = 0$$

From the second equation of motion–

$$s = u_r t + \frac{1}{2}at^2$$

$$2.7 = 0 + \frac{1}{2} \times 11 \times t^2$$

$$t^2 = \frac{5.4}{11}$$

$$t = \sqrt{\frac{5.4}{11}}\,s$$

751. A balloon is rising vertically up with a velocity of 29 ms^{-1}. A stone is dropped from it and it reaches the ground in 10 s. The height of the balloon when the stone was dropped from it is (g = 9.8 ms^{-2})

(a) 400 m (b) 150 m

(c) 100 m (d) 200 m

Manipal UGET-2012

Ans. (d) : Given, u = 29m/s, t = 10s

From second equation of motion –

$$s = ut + \frac{1}{2}at^2$$

$$s = [-29 \times 10] + \frac{1}{2}[9.8 \times 100]$$

$$s = -29 \times 10 + \frac{1}{2} \times 980$$

$$s = -290 + 490$$

$$s = 200\text{m}$$

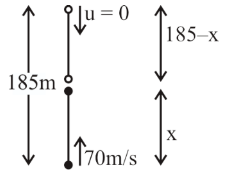
752. A ball is thrown vertically upward with speed 70 m/s. After 1s, another ball is dropped from a height 185 m in the same vertical line. At what height the balls collide?

(a) 150 m (b) 160 m

(c) 168 m (d) 165 m

JCECE-2016

Ans. (d) :



For first ball,

$$s_1 = ut + \frac{1}{2}gt^2$$

$$s_1 = 70 \times t - \frac{1}{2} \times 10 \times t^2$$

$s_1 = 70\,t - 5\,t^2$ ……….(i)

For second ball,

$$s_2 = ut + \frac{1}{2}gt^2 \qquad (\because t = 1)$$

$$185 - s_1 = \frac{1}{2}g(t-1)^2$$

$185 - s_1 = 5(t-1)^2$ …….(ii)

Add equation (i) and (ii), we get–

$$185 = 70\,t - 5t^2 + 5\,(t-1)^2$$

$$185 = 70\,t - 5t^2 + 5t^2 + 5 - 2.t.1 \times 5$$

$$185 = 60t + 5$$

$$t = 3 \text{ sec.}$$

Put the value of t in equation (i), we get–

$$s_1 = 70\,t - 5t^2$$

$$s_1 = 70 \times 3 - 5 \times (3)^2$$

$$s_1 = 210 - 45$$

$$s_1 = 165$$

At 165m the balls are collide.

753. A ball is dropped from the top of the building 100 m high. Simultaneously, another ball is thrown upwards from the bottom of the building with such a velocity that the balls collide exactly mid-way. What is the speed in m s^{-1} with which the second ball is thrown? (Take g=10 m s^{-2})

(a) 31.6 (b) 27.8

(c) 22.4 (d) 19.6

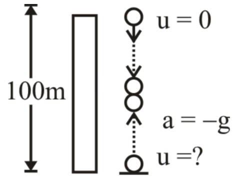
COMEDK 2015

Ans. (a) : Time taken by the first ball reach 50 m

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 50}{10}} = \sqrt{10}\,s = 3.2\,\text{sec}.$$

The ball thrown from bottom should reach 50 m.

(a = – g)



$$s = ut - \left(\frac{1}{2}\right) \times g \times t^2 \text{......(i)}$$

$$50 = u(3.2) - \frac{1}{2}(9.8) \times (3.2)^2$$

u = 31.4 ≈ 31.6 m/sec , the approx value

754. A man of mass 60 kg records his wt. on a weighing machine placed inside a lift. The ratio of wts. of man recorded when lift ascending up with a uniform speed of 2 m/s to when it is descending down with a uniform speed of 4 m/s will be

(a) 0.5 (b) 1

(c) 2 (d) None of these

AIIMS-2007

Ans. (b) : In case of ascending:

$$\text{Weight}, W_1 = m\,(g + a) \qquad (\because a = 0)$$

$$W_1 = mg$$

$$= 60 \times 10 = 600 \text{ N}$$

In case of descending

$$W_2 = m\,(g - a)$$

$$W_2 = mg \qquad (\because a = 0)$$

$$= 60 \times 10 = 600 \text{ N}$$

In uniform speed/motion, either ascending up or descending down, acceleration of lift a= 0

@apna_pdf

that's why, there is only gravity acceleration in both cases.

So, $W_1 = W_2 = mg$

Ratio $\frac{W_1}{W_2} = \frac{60}{60} = 1$

Uniform speed will not affect his weight.

755. Assertion : If a body is thrown upwards, the distance covered by it in the last second of upward motion is about 5 m irrespective of its initial speed

Reason : The distance covered in the last second of upward motion is equal to that covered in the first second of downward motion when the particle is dropped.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2000

Ans. (a) : For the distance covered in the last second final velocity become zero. As the physical scenario must be same, so, if we drop a body then it must travel the same distance in first second as that covered in lost second of upward motion.

Downward motion:

$$u = 0, t = 1\text{ s}$$
$$g = 10\text{ m/s}^2$$

Equation of motion,

$$s = ut + \frac{1}{2}gt^2$$
$$s = 0 + \frac{1}{2}\times 10$$
$$s = 5\text{m}$$

756. Assertion: Two balls of different masses are thrown vertically upward with same speed. They will pass through their point of projection in the downward direction with the same speed.

Reason: The maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2013

Ans. (a) : From equation of motion

$$h = ut - \frac{1}{2}gt^2 \qquad ....(i)$$
$$v^2 = u^2 - 2gh \qquad ....(ii)$$

By the above equation, there is no relation between height and mass or downward velocity and mass.

So, the maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.

∴ These equation are independent of mass.

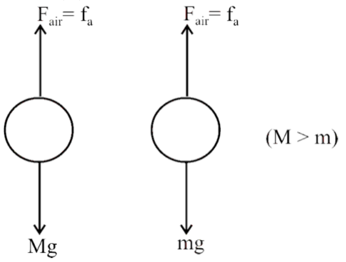
757. Assertion: The two bodies of masses M and m (M > m) are allowed to fall from the same height. If the air resistance for each be the same then both the bodies will reach the earth simultaneously.

Reason: For same air resistance, acceleration of both the bodies will be same.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2014

Ans. (d) :



Acceleration of the Ist body, $(a) = g - \frac{f_a}{M}$

Acceleration of the IInd body, $(a)\ g - \frac{f_a}{m}$

$$\therefore g - \frac{f_a}{M} > g - \frac{f_a}{m}$$

$(a)_M > (a)_m$

Therefore, the body with large mass will have greater acceleration and it will reach the ground first.

758. Assertion: In a free fall, weight of a body becomes effectively zero.

Reason: Acceleration due to gravity acting on a body having free fall is zero.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2014

@apna_pdf

Ans. (c) : In a free fall weight of a body become effectively zero. The reason behind it is the normal force acting on the object is equal to n × g which is same as the weight of the object. So the object feels weightless. Actual weight during free fall is mg. The acceleration due to gravity on the object falling down is 9.8 m/s^2. It is not zero.

759. Two bodies begin a free fall from the same height at a time interval of N s. If vertical separation between the two bodies is 1 after n second from the start of the first body, then n is equal to

(a) $\sqrt{nN}$ (b) $\frac{1}{gN}$

(c) $\frac{1}{gN}+\frac{N}{2}$ (d) $\frac{1}{gN}-\frac{N}{4}$

AIIMS-2016

Ans. (c) : Distance travelled by first body

$$h_1 = ut + \frac{1}{2}gt^2$$

$$h_1 = 0 + \frac{1}{2}gn^2 \ldots\ldots \text{(i)}$$

Distance travelled by second body.

$$h_2 = \frac{1}{2}g(n-N)^2 \ldots\text{(ii)}$$

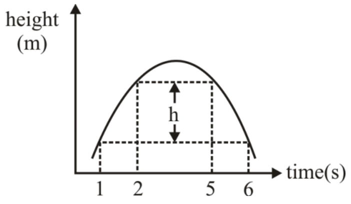
From equation (i) and (ii)

$$h_1 - h_2 = \frac{1}{2}g\left[n^2-(n-N)^2\right]$$

$$1 = \frac{g}{2}(2n-N)N \quad [\therefore h_1 - h_2 = 1]$$

$$n = \frac{1}{gN}+\frac{N}{2}$$

760. A ball is thrown upwards. Its height varies with time as follows:



If the acceleration due to gravity is 7.5 m/s^2, then the height h is :

(a) 10m (b) 15m

(c) 20m (d) 25m

AIIMS-2011

Ans. (b) : Velocity of ball at highest point is zero.

$v = 0$, $a = 7.5$ m/s^2, $t = 3.5$ sec

$v = u - at$

$u = 7.5 \times 3.5 = 26.25$ m/s

At ,

$t = 1$

$$h_1 = ut - \frac{1}{2}at^2$$

$$= u \times 1 - \frac{1}{2}\times 7.5\times(1)^2$$

At,

$t = 2$,

$$h_2 = ut - \frac{1}{2}at^2$$

$$= u \times 2 - \frac{1}{2}\times 7.5\times(2)^2$$

$$h = h_2 - h_1$$

$$u - \frac{7.5}{2}\times 3 = 26.25 - 11.25$$

$$= 15\text{m}$$

761. A body is thrown vertically upwards with a velocity of 19.6 ms^{-1}. The position of the body after 4 s will be

(a) at the highest point

(b) at the mid-point of the line joining the starting point and the highest point

(c) at the starting point

(d) none of the above

AIIMS-2009

Ans. (c) : Given,

$u = 19.6$ m/s

$v = 0$

Time taken by the particle to reach the highest point

$v = u - gt$

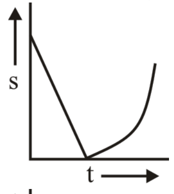
$$t = \frac{u-v}{g}$$

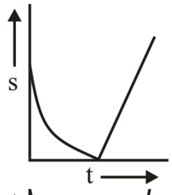
$$= \frac{19.60-0}{9.8} = 2$$

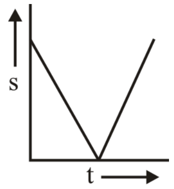
$t = 2$s

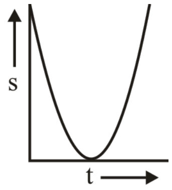
So, the particle position after 4s (2s for upward + 2s for downward) is started point.

762. A ball is thrown vertically upwards. Which of the following plots represents the speed-time graph of the ball during its flight if the air resistance is not ignored?

(a)


(b)


(c)


(d)


AIIMS-2003

Ans. (c) Ball is thrown vertically upward,

$$a = \frac{-mg+R}{m}$$

$$a = -\left(g+\frac{R}{m}\right)$$

From,

$v = u + at$

@apna_pdf

$$v = -\left(g+\frac{R}{m}\right)t+u$$

$$y = -mx + c$$

Ball is thrown vertically downward

$$a = \frac{mg-R}{m}$$

$$= g-\frac{R}{m}$$

From, $v = u + at$

$$= u + \left(g-\frac{R}{m}\right)t$$

$$v = \left(g-\frac{R}{m}\right)t + u$$

$$y = mx + c$$

Plot (c) is represent the speed - time graph of the ball.

763. A ball is dropped from a bridge 122.5 m high. After the first ball has fallen for 2 second, a second ball is thrown straight down after it, what must be the initial velocity of the second ball be, so that both the balls hit the surface of water at the same time?

(a) 26.1 m/s (b) 9.8 m/s

(c) 55.5 m/s (d) 49 m/s

AIIMS-1997

Ans. (a) : For first ball, $h = 122.5m$

$$h = \frac{1}{2}gt^2$$

$$122.5 = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2\times122.5}{10}}$$

$t = 5$ sec.

For second ball, $t = 5 - 2 = 3$ sec.

$$h = ut + \frac{1}{2}gt^2$$

$$122.5 = u \times 3 + \frac{1}{2}\times9.8\times(3)^2$$

$$122.5 = 3 \times u + 44.1$$

$$u = \frac{122.5-44.1}{3} = 26.1\,m/s$$

764. From the top of a building 40m tall, a boy projects a stone vertically upwards with an initial velocity $10ms^{-1}$ such that it eventually falls to the ground. After how long will the stone strike the ground? Take $g = 10\ ms^{-2}$

(a) 1s (b) 2s

(c) 3s (d) 4s

BCECE-2009

Ans. (d) : Given

Building height, $h = 40m$

$u = -10$ m/s

Time taken of stone to reach the ground

$$h = ut + \frac{1}{2}gt^2$$

$$40 = -10 \times t + \frac{10}{2}\times t^2$$

$$5t^2 - 10t - 40 = 0$$

$$t^2 - 2t - 8 = 0 \Rightarrow t^2 - 4t + 2t - 8 = 0$$

$$t(t-4) + 2(t-4) = 0$$

$$(t-4)(t+2)$$

$t = 4s$.

765. A mountaineer standing on the edge of a cliff 441 m above the ground throws a stone horizontally with an initial speed of 20 m s^{-1}. What is the speed with which the stone reaches the ground?

(a) 90 m s^{-1} (b) 95.08 m s^{-1}

(c) 85 m s^{-1} (d) 92 m s^{-1}

J&K-CET-2014

Ans. (b) : Given,

$$u = 20\ m/s$$

$$h = 441m$$

$$v^2 = u^2 + 2gh$$

$$v^2 = 20^2 + 2\times9.8\times441$$

$$v^2 = 400 + 8643.6$$

$$v = \sqrt{9043.6}$$

$$v = 95.08\ m/s$$

766. A constant retarding force of 80 N is applied to a body of mass 50 kg which is moving initially with a speed of 20 m/s. What would be the time required by the body to come to rest?

(a) 15 s (b) 14 s

(c) 12.5 s (d) 18 s

J&K-CET-2014

Ans. (c) : Given,

$$F = 80N$$

$$m = 50kg$$

$$u = 20m/s$$

$$v = 0\ m/s$$

$$a = \frac{F}{m}$$

$$a = \frac{80}{50} = 1.6\ m/s^2$$

Now,

$$v = u + at$$

$$0 = 20 + (-1.6)\times t$$

$$t = 12.5\ sec$$

767. A body is thrown vertically upward from a point A 125 m above the ground. It goes up to a maximum height of 250 m above the ground and passes through A on its downward journey. The velocity of the body when it is at a height of 70 m above the ground is ($g=10ms^{-2}$)

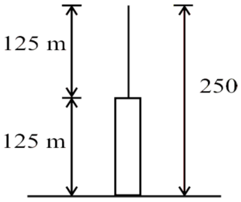
(a) 50 ms^{-1} (b) 60 ms^{-1}

(c) 80 ms^{-1} (d) 20 ms^{-1}

AP EAMCET(Medical)-2013

@apna_pdf

Ans. (b) : Given that,
Height of point = 125 m
Maximum height of body = 250 m
Displacement = 250 m



Covered distance = (250 – 70)
= 180 m
Initial velocity, u = 0
Gravitational acceleration
$g = 10\ m/sec^2$
By Newton's third law of motion

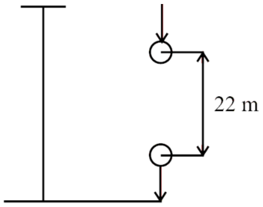
$$v^2 = u^2 + 2gh$$
$$v^2 = 0 + 2 \times (-10) \times (-180)$$
$$= 2 \times 1800$$
$$= 3600$$
$$v = \sqrt{3600}$$
$$v = 60\ m/sec$$

768. A stone is dropped freely, while another is thrown vertically downward with an initial velocity at 2 m/s from the same point, simultaneously. The time required by them to have a distance of separation 22 m between them is:

(a) 11s (b) 5.5s
(c) 44s (d) 22s

AP EAMCET(Medical)-1999

Ans. (a) : Given that,
Downward velocity of body = 2 m/sec
Relative velocity = 2 – 0
The separated distance, (Δs) = 22 m



Distance = velocity × time

$$\Delta s = v \times t$$
$$22 = 2 \times t$$
$$t = \frac{22}{2}$$
$$t = 11\ sec$$

769. A ball is dropped from height h and another from 2h. The ratio of time taken by the two balls to reach ground is

(a) $1:\sqrt{2}$ (b) $\sqrt{2}:1$
(c) 2 : 1 (d) 1 : 2

UP CPMT-2003

Ans. (a) : Given that,
A ball is dropped from height h and another from 2h
We know that,

$$\text{Time } (t_1) = \sqrt{\frac{2h}{g}} \quad \_\_\_\_(i)$$

$$\text{And time } (t_2) = \sqrt{\frac{2(2h)}{g}} \quad \_\_\_\_(ii)$$

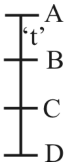
On dividing equation (i) by equation (ii) we get-

$$\frac{t_1}{t_2} = \frac{\sqrt{\frac{2h}{g}}}{\sqrt{2\frac{(2h)}{g}}}$$

$$\frac{t_1}{t_2} = \frac{1}{\sqrt{2}}$$

$$\therefore \quad t_1 : t_2 = 1 : \sqrt{2}$$

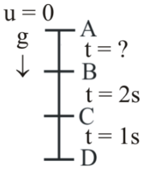
770. A body is falling freely from a point A at a certain height from the ground and passes through points B, C and D (vertically as shown below) so that BC=CD. The time taken by the particle to move from B to C is 2 seconds and from C to D is 1 second. Time taken to move from A to B in seconds is



(a) 0.6 (b) 0.5
(c) 0.2 (d) 0.4

TS EAMCET (Engg.)-2016

Ans. (b) :



Given,

$$BC = CD$$
$$BD = BC + CD$$
$$BD = 2BC \ldots\ldots\ldots\ldots\ldots(i)$$

Now, $s = ut + \frac{1}{2}at^2$

$$2BC = (2v + \frac{1}{2}g \times 2^2) \times 2 = (2v + 2g) \times 2 \quad \ldots.(ii)$$

$$BD = v \times 3 + \frac{1}{2}g\,(3)^2$$

$$= 3v + \frac{9}{2}g\ldots\ldots\ldots(iii)$$

From equation (ii) and (iii)

$$3v + \frac{9}{2}g = (2v + 2g) \times 2$$

@apna_pdf

$3v + 4.5g = 4v + 4g$

$v = 0.5\,g$

$\because \quad v = u + at$

$0.5 \times g = 0 + gt$

$t = 0.5$ sec

771. A ball is thrown vertically upwards. It has a speed of 10 m/s when it has reached one half of its maximum height. How high does the ball rise? g = 10 m^2

(a) 10 m (b) 5 m

(c) 15 m (d) 20 m

SRM JEE - 2010

Ans. (a) : Maximum height reached by particle is given by

$$H_{max} = \frac{u^2}{2g} \qquad \ldots (i)$$

[u = initial velocity]

Now, from eq. of motion

$v^2 - u^2 = -2as$

At half the maximum height,

$$100 - u^2 = -2g\left(\frac{u^2}{4g}\right)$$

$$100 - u^2 = \frac{-u^2}{2} \Rightarrow \frac{u^2}{2} = 100$$

$u^2 = 200$ m/s

Substituting in eq.(i), we get

$$H_{max} = \frac{200}{2 \times 10} = 10\text{m}$$

772. A ball is dropped from a height of 19.6 m. The distance covered by it in the last second is

(a) 19.6m (b) 14.7m

(c) 4.8m (d) 9.8m

SRMJEE - 2016

Ans. (b) : Height, h = 19.6 m, g = 9.8

$$h = ut + \frac{1}{2}gt^2$$

initial velocity, u = 0

$$\therefore \quad h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}} \Rightarrow t = \sqrt{\frac{2 \times 19.6}{9.8}} = 2s$$

$\therefore$ The distance covered in last second will be

$$h = u + \frac{1}{2}g(2t - 1)$$

$$= 0 + \frac{1}{2} \times 9.8 \times (4 - 1)$$

$h = 4.9 \times 3 = 14.7$

773. When a ball is thrown up vertically with a velocity v_0 it reaches a height h. If one wishes to triple the maximum height, then the ball should be thrown with a velocity of

(a) $\sqrt{3}v_0$ (b) $3v_0$

(c) $9v_0$ (d) $3/2v_0$

SRMJEE - 2016

Ans. (a) : Here initial velocity, u = v_0

Height reached = h

At highest point final velocity (v) will be zero.

From equation of motion, $v^2 - u^2 = 2as$

$$0 - v_0^2 = -2gh \Rightarrow h = \frac{v_0^2}{2g}$$

For thrice the maximum height (3h),

$$0 - v_0'^2 = -2g\left(\frac{3v_0^2}{2g}\right)$$

$$\left(v_0' = \text{new initial velocity}\right)$$

$$v_0'^2 = 3v_0^2 \Rightarrow v_0' = \sqrt{3}v_0$$

774. A body is thrown vertically upwards from the ground. It reaches a maximum height of 20 m in 5s. After what time it will reach the ground from its maximum height position?

(a) 2.5 s (b) 5 s

(c) 10 s (d) 25 s

[AIPMT 1995]

Ans. (b) : Let, u the initial velocity and v is the final velocity. When the body moves in upwards direction its velocity is u and when it reaches its maximum height its velocity is zero. i.e. v = 0.

i.e. it takes same time to reach ground.

so, t = 5 sec.

775. A stone released with zero velocity from the top of a tower, reaches the ground in 4 s. The height of the tower is (g =10 m /s^2)

(a) 20 m (b) 40 m

(c) 80 m (d) 160 m

[AIPMT 1995]

Ans. (c) : Given that,

t = 4 sec, u = 0 g = 10 m/s^2

(From the equation of motion)

$$s = ut - \frac{1}{2}gt^2$$

$$s = 0 \times 4 - \frac{1}{2} \times 10 \times 4 \times 4$$

$s = 80$m

776. If a ball is thrown vertically upwards with a velocity of 40m /s, then velocity of the ball after 2s will be (g = 10m/ s^2)

(a) 15 m/s (b) 20 m/s

(c) 25 m/s (d) 28 m/s

[AIPMT 1996]

Ans. (b) : Given that,

u = 40 m/s, t = 2s

g = 10 m/s^2

a = –g

v = u + at

v = 40 +(–10) × 2

v = 40 – 20 ⇒ v = 20 m/s

777. A stone is thrown vertically upwards. When stone is at a height half of its maximum height, its speed is 10 m/s, then the maximum height attained by the stone is (g =10m /s^2)

@apna_pdf

(a) 8 m (b) 10 m
(c) 15 m (d) 20 m

[AIPMT 2001]

Ans. (b) :

$$v^2 - u^2 = 2gh$$
$$0 - u^2 = 2gh$$
$$\therefore \quad u = \sqrt{2gh}$$

At h/2, $g = 10\ m/s^2$

$$10^2 - u^2 = -2gh/2$$
$$100 - 2gh = -gh$$
$$h = \frac{100}{10} = 10m$$

778. Two bodies A (of mass 1 kg) and B (of mass 3 kg) are dropped from heights of 16mand 25 m, respectively. The ratio of the time taken by them to reach the ground is

(a) –5/4 (b) 12/5
(c) 5/12 (d) 4/5

[AIPMT 2006]

Ans. (d) : $\because h = ut + \frac{1}{2}gt^2 \qquad [\because u = 0]$

$$h = \frac{1}{2}gt^2$$
$$\because h \propto t^2$$
$$\frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$$

779. A stone falls freely under gravity. It covers distances h_1 h_2, and h_3 in the first 5s, the next 5s and the next 5s respectively. The relation between h_1, h_2, and h_3 is

(a) $h_1 = 2h_2 = 3h_3$

(b) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$

(c) $h_2 = 3h_1$ and $h_3 = 3h_2$

(d) $h_1 = h_2 = h_3$

[NEET 2013]

Ans. (b) : $h_1 = \frac{1}{2}gt^2 = \frac{1}{2}\times10\times5^2 = 125 \quad \ldots(i)$

$$h_2 = \frac{1}{2}\times10\times10\times10 - \frac{1}{2}\times10\times5\times5 = 375 \quad \ldots(ii)$$
$$h_3 = \frac{1}{2}\times10\times15\times15 - \frac{1}{2}\times10\times10\times10 = 625 \quad \ldots.(iii)$$

From equation (i), (ii) and (iii), we get

$$h_1 = \frac{h_2}{3} = \frac{h_3}{5}$$

780. A boy standing at the top of a tower of 20m height drops a stone. Assuming, g =10 ms^{-2}, the velocity with which it hits the ground is

(a) 20 m/s (b) 40 m/s
(c) 5 m/s (d) 10 m/s

[AIPMT 2011]

Ans. (a) : We know,

$$v^2 = u^2 + 2gh$$
$$u = 0$$
$$v = \sqrt{(2gh)} \Rightarrow v = \sqrt{2\times10\times20}$$
$$v = \sqrt{400} \Rightarrow v = 20\,m/s$$

781. A ball is thrown vertically upward. It has a speed of 10 m/s when it has reached one-half of its maximum height. How high does the ball rise? (Take, g = 10 m/s^2)

(a) 15 m (b) 10 m
(c) 20 m (d) 5 m

JIPMER- 2007

Ans. (b) : Given that,

$v = 0, \quad u = 10\ m/s, \quad g = 10\ m/s^2$

We know that,

$$v^2 = u^2 - 2gh$$
$$0 = u^2 - 2g(h/2)$$
$$h = \frac{u^2}{g} = \frac{10\times10}{10} = 10\ m$$

782. A stone is dropped from a balloon going up with uniform velocity of 5.0 m/s. If the balloon was 50m high when the stone was dropped, then its height when the stone hits the ground is (g = 10 m/s^2)

(a) 18.5 m (b) 60.0 m
(c) 68.5 m (d) 55.0 m

Assam CEE-2014

Ans. (c) : We know that,

$$s = ut + \frac{1}{2}at^2$$
$$-50 = 5(t) + \frac{1}{2}(-10)t^2$$
$$-50 = 5t - 5t^2$$
$$5t^2 - 5t - 50 = 0$$
$$t^2 - t - 10 = 0$$

From quadratic equation,

$$t = \frac{-(-1)\pm\sqrt{(1)^2 - 4\times1\times(-10)}}{2\times1} = \frac{1\pm\sqrt{41}}{2}$$

t = 3.70 sec (taking positive sign)

So, height of balloon from ground at this instant is

$$h = 50 + 3.7 \times 5$$
$$h = 68.5\ m$$

783. On dropping a stone onto a well of depth 80m, the splash is heard after 4.25 seconds. Then the velocity of sound in air is (g = 10 m/s^2)

(a) 300 m/s (b) 320 m/s
(c) 340 m/s (d) None of the above

Assam CEE-2014

Ans. (b) : Time taken by stone to reach the bottom of the well is given by using, $s = ut + \frac{1}{2}gt^2$

Where, s = 80 m and u = 0

$$s = 0 \times t + \frac{1}{2}t^2$$

@apna_pdf

$$80 = \frac{1}{2} \times 10 \times t^2 \Rightarrow t^2 = \frac{80 \times 2}{10}$$

$$t = \sqrt{\frac{160}{10}} \Rightarrow t = 4 \text{ sec}$$

So, time taken by sound to travel 80 m is

$$(4.25 - 4)\text{s} = 0.25 \text{ s}$$

$$\therefore \text{ Velocity of sound in air, } v_{air} = \frac{\text{Distance}}{\text{time}} = \frac{80}{0.25}$$

$$v_{air} = \frac{80 \times 100}{25}$$

$$v_{air} = 320 \text{ m/s}$$

784. A, B, C are points in a vertical line that AB = BC If a body falls freely from rest at A, And t_1 and t_2 are times taken to travel distances AB and BC, then ratio (t_2/t_1) is

(a) $\sqrt{2}+1$ (b) $\sqrt{2}-1$

(c) $2\sqrt{2}$ (d) $\frac{1}{\sqrt{2}+1}$

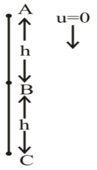
TS EAMCET (Engg.)-2015

Ans. (b): Let AB = h = BC

Then AC = 2h

Time taken to travel distance (AB =h) is t_1.

$$h = ut_1 + \frac{1}{2}gt_1^2$$



$$h = 0 + \frac{1}{2}gt_1^2 \qquad \{\because u = 0$$

$$t_1 = \sqrt{\frac{2h}{g}} \qquad \text{....(i)}$$

Time taken by body to travel distance (AC=2h) is (t_1+t_2)

$$\text{So, } 2h = \frac{1}{2}g(t_1 + t_2)^2$$

$$\frac{4h}{g} = (t_1 + t_2)^2 \Rightarrow t_1 + t_2 = \sqrt{\frac{4h}{g}}$$

$$t_2 = \sqrt{\frac{4h}{g}} - t_1 \qquad \text{...(ii)}$$

$$= \sqrt{\frac{4h}{g}} - \sqrt{\frac{2h}{g}} \Rightarrow t_2 = \left(\sqrt{2}-1\right)\sqrt{\frac{2h}{g}}$$

From equation (i) & (ii), we get

$$\left(\frac{t_2}{t_1}\right) = \frac{\left(\sqrt{2}-1\right)\sqrt{\frac{2h}{g}}}{\sqrt{\frac{2h}{g}}} = \sqrt{2}-1$$

785. A body is thrown upward against the gravity 'g' with initial velocity 'u'. Which one among the following is the correct expression for its final velocity when attains the maximum height?

(a) $u^2/(2g)$ (b) $2g/u^2$

(c) $u^2g/2$ (d) None of the above

NDA (II) 2011

Ans. (d) : Initial velocity = u

g– acceleration due to gravity

for maximum height,

$$v^2 = u^2 + 2gh \qquad (u = 0)$$

$$v = \sqrt{2gh}$$

786. A bullet is fired vertically up from a 400 m tall tower with a speed 80 m/s. If *g* is taken as 10 m/s², the time taken by the bullet to reach the ground will be

(a) 8 s (b) 16 s

(c) 20 s (d) 24 s

NDA (II) 2014

Ans. (c) : According to question

Height of tower = 400 m

Initial fired velocity u = 80 m/s

$g = 10 \text{ m/s}^2$

On going A to B

$$\text{Time taken } (t_1) = \frac{u}{g} = \frac{80}{10} = 8 \text{sec}$$

$$h = ut - \frac{1}{2}gt^2 \Rightarrow h = 80 \times 8 - \frac{1}{2} \times 10 \times 64$$

$$h = 640 - 320 \Rightarrow h = 320$$

$$H = 320 + 400 \Rightarrow H = 720$$

Then,

$$t_2 = \sqrt{2H/g}$$

$$t_2 = \sqrt{\frac{2 \times 720}{10}} = \sqrt{144} = \sqrt{12 \times 12} = 12 \text{sec}$$

So, total time taken to reach the ground be $T = t_1 + t_2$

$= 8 + 12 = 20$ sec.

787. A body has a free fall from a height of 20 m. After falling through a distance of 5 m, the body would

(a) lose one-fourth of its total energy

(b) lose one-fourth of its potential energy

(c) gain one-fourth of its potential energy

(d) gain three-fourth of its total energy

NDA (I) 2016

Ans. (b) : According to law of conservation of energy

PE = mgh = 20 mg

Loss in $(PE)_1$ = mgh = 5 mg

$$\frac{(PE)_1}{PE} = \frac{5mg}{20mg} = \frac{1}{4}$$

$$(PE)_1 = \frac{1}{4}PE$$

@apna_pdf

788. Two bullets are fired simultaneously, horizontally and with different speeds from the same place. Which bullet will hit the ground first?

(a) The faster bullet
(b) The slower bullet
(c) Both will hit simultaneously
(d) Depends on the masses

UPSEE - 2008

Ans. (c) : As we know

$$h = ut + \frac{1}{2}gt^2 \Rightarrow h = 0 + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}}$$

So, we see that time of flight does not depend upon velocity.

So, both the bullet will hit simultaneously at the ground.

789. A body falling from rest has a velocity v after it falls through a distance h. The distance it has to fall down further, for its velocity to become double, is .... times h.

(a) 5 h	(b) h
(c) 2 h	(d) 3 h

EAMCET-1991

Ans. (d) : The body is falling freely under gravity, so the gravitational acceleration = a = g

The initial velocity of the body = N = 0

After initial velocity of the body = u = 0

After covering distance = h

The velocity becomes = v

So, $v^2 - u^2 = 2gh$ $(u = 0)$

$v^2 = 2gh$

After sometimes (t) its velocity becomes double = v' = 2v

Net the distance covered in time (t) = h'

Here initial velocity = v

So, $v'^2 - v^2 = 2gh$

$(2v)^2 - v^2 = 2gh' \Rightarrow 4v^2 - v^2 = 2gh'$

$3v^2 = 2gh$

$3(2gh) = (2gh')$ $[v^2 = 2gh]$

$3h = h'$

These h' is 3 times h.

790. A wooden block is dropped from the top of a cliff 100 m high. Simultaneously a bullet of mass 10 g is fired from the foot of the cliff upwards with a velocity of 100 ms^{-1}. The bullet and wooden block will meet each other after a time

(a) 10 s	(b) 0.5 s
(c) 1 s	(d) 7 s

EAMCET-1991

Ans. (c) : Let us assume they both meed each other after t second. Now if the block is travelling 'x' distance the bullet will travel (100–x) distance in the same amount of time

Solving for block

$$X = ut + \frac{1}{2}gt^2$$

$$X = 0 \times t + \frac{1}{2} \times 10 \times t^2$$

$X = 5t^2$

Solving for bullet

$100 - x = 100 \times t + 1/2\,(-10)\,t^2$

$100 - x = 100\,t - 5t^2$

$100 - x = 100\,t - x$

$100 = 100\,t$

t = 1 second

791. A ball is thrown vertically up with a velocity of 4.9 m/s. The ball is then collected by the person on ground after a time interval of

(a) 3.0 s	(b) 2.0 s
(c) 1.0 s	(d) 0.5 s

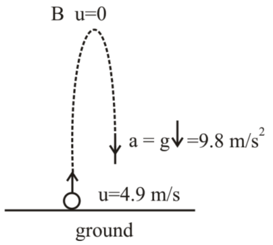
AMU-2007

Ans. (d) : In question,

Initial velocity of ball, μ =4.9 m/s

Acceleration, $a = 9.8\,m/s^2\,(g = \text{Assume})$

Let, high $_{max}$ =H



Time = t

Velocity of ball at paint B, v = 0

Putting the second law of motion, $v^2 = u^2 + 2as$

$$\Rightarrow 0 = (4.9)^2 - 2 \times 9.8 \times H_{max} \Rightarrow H_{max} = 1.225m$$

From first equation of motion, v = u + at

$$0 = 4\cdot9 - 9\cdot8 \times t \Rightarrow t = \frac{4\cdot9}{9\cdot8} = 0.5\,sec$$

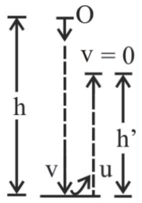
792. A ball which is at rest is dropped from a height h meter. As it bounces off the floor its speed is 80% of what is was just before touching the ground. The ball will then rise to nearly a height:

(a) 0.94 h	(b) 0.80 h
(c) 0.75 h	(d) 0.64 h
(e) 0.50 h	

Kerala CEE 2004

Ans. (d) : The ball at rest is dropped from height h.

So, u = 0 m/s, a = g, s = h m



@apna_pdf

As, $v^2 = u^2 + 2as$

so, $v^2 = 0 + 2 \times g \times h$

$v = \sqrt{2gh}$

Now after rebounded, the velocity reduced to 80% of the initial

So, $u = 0.80 \times \sqrt{2gh}$

And final velocity at new height h' will be

$v = 0$ (m/s)

So, $v^2 = u^2 - 2gh'$

$$0 = \left(0.80\sqrt{2gh}\right)^2 - 2gh' \Rightarrow h' = \frac{\left(0.80\sqrt{2gh}\right)^2}{2g}$$

$h' = 0.64\ h$

793. A body from height h is dropped. If the coefficient of restitution is e, then calculate the height achieved after one bounce.

(a) $h_1 = e^2h$ (b) $h_1 = e^4h$

(c) $h_1 = eh$ (d) $h_1 = \frac{h}{e}$

UP CPMT-2007

Ans. (a) : Given, Height = h

Coefficient of restitution = e

Height after one bounce = ?

We know, when a body falls from the height 'h' and it strikes the ground with velocity 'u',

So, $u = \sqrt{2gh}$

Let, ball rebounds with velocity 'v' and after rebounds it rise to height 'h_1'

So, $v = \sqrt{2gh_1}$

$\because \quad e = \frac{v}{u}$

$$e = \frac{\sqrt{2gh_1}}{\sqrt{2gh}}$$

$$e = \frac{\sqrt{h_1}}{\sqrt{h}}$$

$$e^2 = \frac{h_1}{h}$$

$h_1 = e^2h$

794. A bullet after firing from a gun goes through a plank of thickness h and changes its velocity from u to v. The force of resistance is proportional to square of velocity. The time of motion of the bullet in the plank is proportional to

(a) $(u - v)\ u^{-2}$ (b) $(u - v)\ v^{-2}$

(c) $(u - v)\ (uv)^{-1}$ (d) $(u^2 - v^2)\ (uv)^{-2}$

SCRA-2013

Ans. (c) : According to the question,

$$m\frac{dv}{dt} = -kv^2$$

$$m\frac{dv}{v^2} = -kdt$$

Taking both side integration,

$$\int_u^v \frac{dv}{v^2} = -\frac{k}{m}\int_0^t dt$$

$$t = \frac{m}{k}\frac{(u-v)}{uv}$$

$t \propto (u - v)\ (uv)^{-1}$

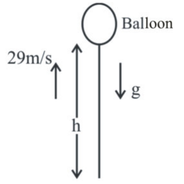
795. A balloon is rising vertically up with a velocity of 29 ms^{-1}. A stone is dropped from it and it reaches the ground in 10 seconds. The height of the balloon when the stone was dropped from it is : (g = 9.8 ms^{-2})

(a) 400 m (b) 150 m (c) 100 m (d) 200 m

Karnataka CET-2004

Ans. (d) : Given,

u = 29 m/s, t = 10 sec



$$h = -ut + \frac{1}{2}gt^2$$

$$h = -29 \times 10 + \frac{1}{2} \times (9.8) \times 10^2$$

$h = -290 + 490$

$h = 200$ m

796. A stone of density 2000 kg m^{-3} completely immersed in a lake is allowed to sink from rest. If the effect of friction is neglected, then after 4 seconds, the stone will reach a depth of

(a) 78.4 m (b) 39.2 m

(c) 19.6 m (d) 9.8 m

(e) 24.6 m

Kerala CEE - 2016

Ans. (b) : Given,

Density of stone (δ_s) = 2000 kg/m^3

Density of water (δ_w) = 1000 kg/m^3

According to question,

$$g' = g\left(1 - \frac{\delta_w}{\delta_s}\right)$$

$$g' = g\left(1 - \frac{1000}{2000}\right)$$

$g' = g/2$

From, second equation of motion,

$$s = ut + \frac{1}{2}g't^2 \qquad \{\because \text{initial velocity } u = 0\}$$

$$\therefore s = \frac{1}{2}g'\,t^2$$

$$s = \frac{1}{2} \times \left(\frac{g}{2}\right) \times (4)^2$$

$$s = \frac{1}{2} \times \frac{9.8}{2} \times (4)^2 = 39.2 \text{ m}$$

@apna_pdf

797. A ball dropped from a point A falls down vertically to C, through the mid-point B. The descending time from A to B and that from A to C are in the ratio

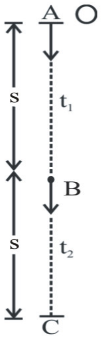
(a) 1 : 1 (b) 1 : 2

(c) 1 : 3 (d) $1:\sqrt{2}$

(e) $1:\sqrt{3}$

Kerala CEE - 2015

Ans. (d) : The given situation is as shown in figure, let the distance between point A and B is s,



Initial velocity u = 0

from second equation of motion,

$$s = ut + \frac{1}{2}gt^2$$

For point A to B, $s = \frac{1}{2} g\, t_1^2$ ....(i)

For point A to C, $2s = \frac{1}{2} g\ t_2^2$ ....(ii)

On dividing eq. (i) by eq. (ii),

$$\frac{t_1^2}{t_2^2} = \frac{1}{2}$$

$$\frac{t_1}{t_2} = \frac{1}{\sqrt{2}}$$

$$t_1 : t_2 = 1 : \sqrt{2}$$

798. From a balloon moving upwards with a velocity of 12 ms^{-1}, a packet is released when it is at a height of 65 m from the ground. The time taken by it to reach the ground is (take, g = 10 ms^{-2})

(a) 5 s (b) 8 s

(c) 4 s (d) 7 s

(e) 10 s

Kerala CEE - 2015

Ans. (a) : Given,

$u = 12\ \text{ms}^{-1}$, $s = -65$ m, $g = -10\ \text{ms}^{-2}$

We know that,

$$s = ut + \frac{1}{2}gt^2$$

$$-65 = 12t - \frac{1}{2} \times 10t^2$$

$$-65 = 12\,t - 5t^2$$

$$5t^2 - 12t - 65 = 0$$

$$5t^2 - 25t + 13t - 65 = 0$$

$$5t\,(t-5) + 13\,(t-5) = 0$$

$$(5t + 13)\,(t-5) = 0$$

$$t = -\frac{13}{5},\quad t = 5\text{ sec}$$

Time taken by balloon to reach on ground is 5sec.

799. A bullet is to be fired with a speed of 2000 ms^{-1} to hit target 200 m away on a level ground. If g = 10 ms^{-2}, the gun should be aimed

(a) directly at the target

(b) 5 cm below the target

(c) 5 cm above the target

(d) 2 cm above the target

(e) 2 cm below the target

Kerala CEE - 2009

Ans. (c) : Given,

Horizontal distance (d) = 200 m

Speed of bullet = 2000 ms^{-1}

Time taken to cover the horizontal distance

$$t = \frac{200}{2000} = \frac{1}{10}\text{sec}$$

During $\frac{1}{10}$sec, the bullet will fall down vertically due to gravitational acceleration.

Therefore, height above the target, so that the bullet hits the target is

$$h = ut + \frac{1}{2}g\,t^2$$

$$h = 0 \times \frac{1}{10} + \frac{1}{2} \times 10 \times (0.1)^2$$

= 0.05 m = 5 cm

800. A ball is thrown vertically upwards with a velocity of 25 ms^{-1} from the top of a tower of height 30 m. How long will it travel before it hits ground?

(a) 6 s (b) 5 s

(c) 4 s (d) 12 s

(e) 10 s

Kerala CEE 2007

Ans. (a) : Given,

Initial velocity, u = 25 m/sec.

Final velocity, v = 0

Height, h = 30 m

From second equation of motion, we have

$$h = ut - \frac{1}{2}gt^2 \text{ (Acceleration against gravity)}$$

$$-30 = 25\,t - \frac{1}{2} \times 10 \times t^2$$

$$-6 = 5t - t^2$$

$$t^2 - 5t - 6 = 0$$

$$(t-6)\,(t+1) = 0$$

$$t = 6\text{ sec}$$

801. A balloon starts rising from the ground with an acceleration of 1.25 ms^{-2} after 8 s, a stone is released from the balloon. The stone will (Taking g = 10 ms^{-2})

@apna_pdf

(a) begin to move down after being released
(b) reach the ground in 4 s
(c) cover a distance of 40 m in reaching the ground
(d) will have a displacement of 50 m

BITSAT-2007

Ans. (b) : Balloon starts rising from the ground
$\therefore$ Initial velocity u = 0
Acceleration (a) = 1.25 ms^{-2}
From the first equation of motion

$$v = u + at$$

After 8 sec velocity will be,

$$v = 0 + 1.25 \times 8$$
$$v = 10 \text{ m/s}$$

Distance covered after 8 sec

$$s = ut + \frac{1}{2}at^2$$
$$s = 0 + \frac{1}{2} \times 1.25 \times (8)^2$$
$$s = 40 \text{ m}$$

Now if stone is released from the balloon,
$u = -10 \text{ ms}^{-1}$, a = g, s = 40

$$40 = -10t + \frac{1}{2} \times 10 \times t^2$$
$$40 = -10t + 5t^2$$
$$5t^2 - 10t - 40 = 0$$

Or $\quad t^2 - 2t - 8 = 0$

$$t^2 - (4 - 2)t - 8 = 0$$
$$t^2 - 4t + 2t - 8 = 0$$
$$t(t - 4) + 2(t - 4) = 0$$
$$t = 4, t \neq -2$$

Hence, the stone will take 4 sec to reach the ground.

802. A bus starts moving with acceleration 2 m/s^2. A cyclist 96 m behind the bus starts simultaneously towards the bus at 20 m/s. After what time will he be able to overtake the bus?

(a) 4 sec (b) 8 sec
(c) 12 sec (d) 16 sec

BITSAT-2006

Ans. (b) : Given that, Initial speed of bus (u) = 0
Speed of cyclist = 20 m/s
Acceleration of bus = 2 m/s^2
Distance between bus and cyclist = 96 m
Let after time t cyclist overtake the bus,
Distance covered by the cyclist in time t = speed × time
So,
Distance covered by cyclist = 20 × t ....(i)
Distance covered by the bus in time t

$$s - 96 = ut + \frac{1}{2}at^2$$
$$s = 96 + \frac{1}{2} \times 2 \times t^2 \text{ ....(ii)}$$

from eqn (i) and (ii)

$$20\,t = 96 + \frac{1}{2} \times 2 \times t^2$$
$$20\,t = 96 + t^2 \Rightarrow t^2 - 20t + 96 = 0$$
$$t^2 - 12t - 8t + 96 = 0$$
$$(t-12)(t-8) = 0$$
$$t = 12, t = 8$$

Hence, min. time required by the cyclist to overtake the bus will be 8 sec.

803. A body, thrown upwards with some velocity reaches the maximum height of 50m. Another body with double the mass thrown up with double the initial velocity will reach a maximum height of

(a) 100 m (b) 200 m
(c) 300 m (d) 400 m

BITSAT-2005

Ans. (b) : We know that maximum height obtained by the body is given by

$$H_{max} = \frac{u^2}{2g} \quad \text{...(i)}$$

Where u = initial velocity
From equation (i) we can

$$H_{max} \propto u^2$$
$$\frac{(H_{max})_1}{(H_{max})_2} = \frac{u_1^2}{u_2^2}$$

if $u_1 = u$ according to question
$u_2 = 2u$

$$\frac{(H_{max})_1}{(H_{max})_2} = \frac{u^2}{4u^2} \Rightarrow \frac{(H_{max})_1}{(H_{max})_2} = \frac{1}{4}$$
$$\frac{50}{(H_{max})_2} = \frac{1}{4} \Rightarrow (H_{max})_2 = 200\,\text{m}$$

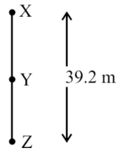
Hence, maximum height will achieved 200 m.

804. A body is dropped from a height 39.2 m. After it crosses half distance the acceleration due to gravity ceases to act. The body will hit the ground with velocity of (Take g = 9.8 m/s)

(a) 19.6 m/s (b) 20 m/s
(c) 1.96 m/s (d) 196 m/s

CG PET- 2010

Ans. (a) : Let a body is dropped from point X as shown in the figure.



Given that,
height XZ = 39.2 m
and Y is mid of XZ.
Initial velocity at point X, $\quad$ u = 0
for XY, h' = h/2
using $v^2 = u^2 + 2gh/2$

$$v^2 = 0 + 2 \times 9.8 \times \frac{39.2}{2}$$
$$v = 19.6 \text{ m/s}$$

Hence, after point Y the body will fall with the same velocity at it passes point Y i.e. 19.6 m/s and hit the ground at Z.

@apna_pdf

805. If a balloon of mass M is descending down with an acceleration a (<g), then what is the value of mass m (of its contents) that must be removed so that it starts moving up with an acceleration 'a'?

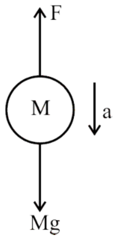
(a) $\frac{Ma}{(g+a)}$ (b) $\frac{2Ma}{(g+a)}$

(c) $\frac{M}{(g+a)}$ (d) Not possible

JCECE-2013

Ans. (b) : If the balloon of mass M is going vertically downward direction

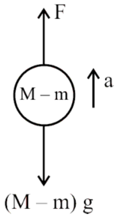
Let force F is acting on the balloon in vertically upward direction



So, Ma = Mg – F

Or F = Mg – Ma ....(i)

if the mass m is reduced from balloon it moves upward with acceleration a,



So, (M –m) a = F – (M –m) g

Put the value of F from equation (i), we get –

(M –m)a = Mg – Ma – (M – m)g

Ma – ma = Mg – Ma – Mg + mg

2Ma = m(a + g)

$$m = \frac{2Ma}{a+g}$$

806. A parachutist drops first freely from an aero plane for 10s and then parachute opens out. Now he descends with a net retardation of 2.5 m/s^2. If he bails out of the plane at a height of 2495 m and g = 10 m/s^2, his velocity on reaching the ground will be

(a) 5 m/s (b) 10 m/s

(c) 15 m/s (d) 20 m/s

JCECE-2011

Ans. (a) : When parachutist jump from an aeroplane

Initial velocity (u) = 0

after 10 sec he opens out parachute

t = 10 sec

velocity acquired by parachutist is given by first equation of motion

v = u + gt

= 0 + 10 × 10

= 100 m/s

and distance travelled by him in 10 sec

$$s_1 = ut + \frac{1}{2}gt^2 = 0 + \frac{1}{2} \times 10 \times 10^2$$

= 500 m

The height when parachutist bails out = 2495 m

Distance travelled in 10 sec = 500 m

Remaining distance s_2 = 2495 – 500 = 1995 m

If the velocity on reaching ground

$$v_2^2 = v^2 + 2as_2 \quad (\because a = -2.5\,m/s^2)$$

$$v_2^2 = (100)^2 + 2 \times (-2.5) \times 1995$$

$$v_2^2 = 25 \Rightarrow v_2 = 5\,m/s$$

807. A stone dropped from a balloon which is at a height h, reaches the ground after t second. From the same balloon, if two stones are thrown, one upwards and the other downwards, with the same velocity u and they reach the ground after t_1 and t_2 second respectively, then

(a) $t = t_1 - t_2$ (b) $t = \frac{t_1 + t_2}{2}$

(c) $t = \sqrt{t_1 t_2}$ (d) $t = \sqrt{t_1^2 - t_2^2}$

JCECE-2010

Ans. (c) : Using second equation of motion

$$s = ut + \frac{1}{2}at^2$$

When stone dropped downwards for distance h,

time = t_2

So, $$h = ut_2 + \frac{1}{2}gt_2^2 \quad \ldots(i)$$

When stone thrown upward for distance h time =t_1

So, $$-h = ut_1 - \frac{1}{2}gt_1^2 \quad \ldots(ii)$$

Equating both equation,

$$ut_2 + \frac{1}{2}gt_2^2 = -\left(ut_1 - \frac{1}{2}gt_1^2\right)$$

$$ut_2 + \frac{1}{2}gt_2^2 = -ut_1 + \frac{1}{2}gt_1^2$$

$$u(t_2 + t_1) = \frac{1}{2}g(t_1^2 - t_2^2)$$

$$u(t_2 + t_1) = \frac{1}{2}g(t_1 + t_2)(t_1 - t_2)$$

$$u = \frac{1}{2}g(t_1 - t_2)$$

Put the value of u in equation (i), we get –

$$h = \frac{1}{2}g(t_1 - t_2)t_2 + \frac{1}{2}gt_2^2 = \frac{1}{2}gt_1t_2 - \frac{1}{2}gt_2^2 + \frac{1}{2}gt_2^2$$

$$h = \frac{1}{2}gt_1t_2 \quad \ldots(iii)$$

When it dropped from balloon

u = 0 time = t

@apna_pdf

and $h = 0 + \frac{1}{2}gt^2$

$$h = \frac{1}{2}gt^2 \qquad \text{…(iv)}$$

Comparing equation (iii) and (iv), we get –

$$\frac{1}{2}gt^2 = \frac{1}{2}gt_1t_2$$

$$t^2 = t_1 t_2$$

$$t = \sqrt{t_1 t_2}$$

808. An elastic ball is dropped from a height h and it rebounds many times from the floor. If the coefficient of restitution is e, the time interval between the second and the third impact, is :

(a) $\frac{ev}{g}$ (b) $\frac{e^2v}{g}$

(c) $e^2\sqrt{\frac{8h}{g}}$ (d) $e^2\sqrt{\left(\frac{h}{g}\right)}$

JCECE-2005

Ans. (c) : Let, initial velocity (u) = 0

From, second equation of motion –

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 + \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

The second impact occurs after an additional time

$$= 2\sqrt{\frac{2h_1}{g}} = 2e\sqrt{2h/g} \qquad (h_1 = e^2h)$$

The third impact occurs after an additional time

$$= 2\sqrt{\frac{2h_2}{g}} = 2e^2\sqrt{2h/g} = e^2\sqrt{8h/g} \qquad (h_2 = e^4h)$$

809. A stone falls freely such that the distance covered by it in the last second of its motion is equal to the distance covered by it in the first 5s. It is in air for :

(a) 26 s (b) 25 s

(c) 13 s (d) 12 s

JCECE-2004

Ans. (c) : From freely falling body:-

Initial velocity. u = 0

Distance travelled in first 5 sec by using second equation of motion,

$$s = ut + \frac{1}{2}gt^2 \Rightarrow s = 0 + \frac{1}{2}g(5)^2$$

Distance travelled in n sec.

$$s_n = \frac{1}{2}gn^2 \text{.......(i)}$$

Distance travelled in (n–1) sec.

$$s_{n-1} = \frac{1}{2}g(n-1)^2 \text{.......(ii)}$$

Distance travelled in last sec.

$$s_{last} = s_n - s_{n-1} = \frac{1}{2}gn^2 - \frac{1}{2}g(n-1)^2$$

$$= \frac{1}{2}g\left[n^2 - \left(n^2 + 1 - 2n\right)\right]$$

$$= \frac{1}{2}g\left(n^2 - n^2 - 1 + 2n\right) = \frac{1}{2}g(2n-1)$$

Now,

distance covered in last second is equal to the distance covered in first 5 sec.

$$s_{last} = s_5 = \frac{g}{2}(2n-1) = \frac{1}{2}g(5)^2$$

$$(2n-1) = 25 \Rightarrow n = 13 \text{ sec.}$$

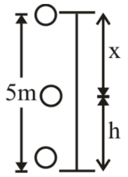
810. Water drops fall at regular intervals from a tap 5 m above the ground. The third drop is leaving the tap at an instant when the first drop touches the ground. The height, in m, of the second drop above the ground at that instant is (Take $g = 10\ \text{m s}^{-2}$)

(a) 1.25 (b) 2.50

(c) 3.75 (d) 5.00

COMEDK 2011

Ans. (c) :



Given,

Height of tap, h = 5m

$g = 10\ \text{m/s}^2$

Time taken by first drop to reach the ground

$$h = ut + \frac{1}{2}gt^2 \Rightarrow 5 = 0 + \frac{1}{2}\times 10\times t^2$$

$t^2 = 1 \Rightarrow t = 1$ sec.

If first drop falls at 0 sec. and second drops at $\frac{1}{2}$ sec, then third drop will fall at 1 sec as they fall on equal time interval.

At, $t = \frac{1}{2}$ s. distance travelled by 2nd drop is.

$$x = \frac{1}{2}gt'^2 = \frac{1}{2}\times 10\left(\frac{1}{2}\right)^2 = \frac{10}{8} = 1.25\text{m}$$

distance above the ground of second drop-

$5 = h + x$

$h = 5 - 1.25$

$h = 3.75$m.

811. A balloon of mass 10 kg is raising up with an acceleration of 20 ms^{-2}. If a mass of 4 kg is removed from the balloon its acceleration becomes (take $g = 10\ \text{ms}^{-2}$)

(a) 40 ms^{-2} (b) 20ms^{-2}

(c) 30 ms^{-2} (d) 12 ms^{-2}

AP EAMCET(Medical)-2015

@apna_pdf

Ans. (a) : Given that,
Mass of balloon = 10 kg
Acceleration = 20 m/sec^2
Removed mass from balloon = 4 kg
Gravity = 10m/s^2
Two forces acted on rising balloon as buoyancy force and gravitational force
Balloon rising with acceleration
F = ma = B – mg

$$B = m(a+g)$$
$$= 10(20+10)$$
$$= 300$$

Remove mass from balloon

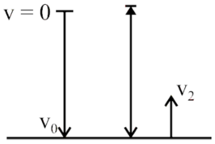
$$B = m'(a+g)$$
$$300 = 6(a+10)$$
$$50 = a+10$$
$$a = 50-10$$
$$= 40 \text{ m/sec}^2$$

812. A ball is thrown vertically upwards from the top of a tower. Velocity at a point h m vertically below the point of projection is twice the downward velocity at a point h m vertically above the point of projection. The maximum height reached by the ball above the top of the tower is

(a) $\frac{4}{3}h$ (b) $\frac{5h}{3}$
(c) 3h (d) 2h

AP EAMCET(Medical)-2012

Ans. (b) : Given that,
Height = h
Velocity of A = $2v_B$
By Newton's third law of motion



$$v^2 = u^2 + 2gh \qquad \text{and } v^2 = u^2 + 2gh$$
$$v_2^2 = v_0^2 - 2gh \text{ .... (i)} \qquad 0 = v_0^2 - 2gH$$
$$v_0^2 = 2gH \text{.......(iii)}$$
$$v_1^2 = u_0^2 + 2gh \text{ ......(ii)}$$

we know that

$$v_1 = 2v_2 \Rightarrow v_1^2 = 4v_2^2$$

from eqn (i) and (ii)

$$v_0^2 + 2gh = 4\left(v_0^2 - 2gh\right)$$
$$v_0^2 + 2gh = 4v_0^2 - 8gh$$
$$3v_0^2 = 10gh$$
$$6gH = 10\,gh \qquad \{\because \text{by eqn (iii)}\}$$

Height = 10/6 h = 5/3 h

813. From the top of a tower, a particle is thrown vertically downwards with a velocity of 10 m/s. The ratio of distances covered by it in the 3rd and 2nd seconds of the motion is (take g = 10 m/s^2)

(a) 5:7 (b) 7:5
(c) 3:6 (d) 6:3

UP CPMT-2010

Ans. (b) : Distance covered in nth second

$$s_n = u + \frac{a}{2}(2n-1)$$
$$\frac{s_{3rd}}{s_{2nd}} = \frac{10+\frac{g}{2}(2\times3-1)}{10+\frac{g}{2}(2\times2-1)}$$
$$= \frac{10+\frac{10}{2}(6-1)}{10+\frac{10}{2}(4-1)} \qquad = \frac{7}{5}$$

$s_{3rd} : s_{2nd} = 7:5$

814. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 ms^{-2}. He reaches the ground with a speed of 3 ms^{-1}. At what height, did he bail out?

(a) 91 m (b) 182 m
(c) 293 m (d) 111 m

AIEEE 2005

Ans. (c) : Given data, h= 50 m, a = – 2ms^{-2}
v = 3ms^{-1}, h' = ?

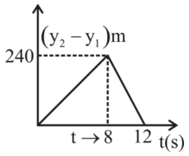
$$\because u = \sqrt{2gh} = \sqrt{2g\times50} = \sqrt{100g}$$

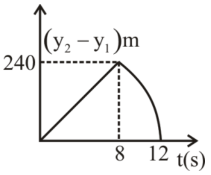
and $v^2 = u^2 + 2ah'$

$$3^2 = \left(\sqrt{100g}\right)^2 + 2(-2)\times h'$$
$$9 = 100\,g - 4h'$$
$$h' = 243\text{m}$$

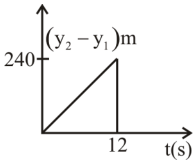
∴ Net height = h + h' = 50 + 243 = 293 m i.e. at the height of 293m , he bail out.

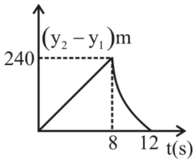
815. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first? Assume stones do not rebound after hitting the ground and neglect air resistance, take g =10 m/s^2)

(a)


(b)


@apna_pdf

(c) 

(d) 

JEE Main 2015

Ans. (b) : For the first stone, $s = ut - \frac{1}{2}gt^2$

$y_1 = -240 = 10t - \frac{1}{2}gt^2 = 10t - \frac{1}{2} \times 10 \times t^2 = 10t - 5t^2$

$\therefore 5t^2 - 10t - 240 = 0$

or $t^2 - 2t - 48 = 0$

$t = 8$sec or -6 sec

i.e. 1st particle will reach the ground in 8 sec

Similarly, for 2nd stone,

$y_2 = -240 = 40t - 5t^2$

$t = 12$ sec

i.e. 2nd particle will strike the ground in 12 sec

$\therefore \Delta y = y_2 - y_1 = 40t - \frac{1}{2}gt^2 - 10t + \frac{1}{2}gt^2 = 30t$

After 8 sec stone 1 reaches ground i.e. $y_1 = -240$ m

$\therefore \Delta y = y_2 - y_1 = 40t - \frac{1}{2}gt^2 + 240$

$\therefore$ It will be a parabolic curve after 8 sec,

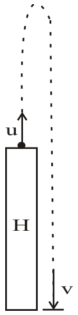
So option (b) is correct.

816. From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle to hit the ground is n times that taken by it to reach the highest point of its path. The relation between H, u and n is

(a) $2gH = n^2u^2$
(b) $gH = (n-2)^2 u^2$
(c) $2gH = nu^2(n-2)$
(d) $gh = (n-2)^2 u^2$

JEE Main 2014

Ans. (c) : From question, we can draw as,



$v = \sqrt{u^2 + 2gH}$

$v = u + at$

$\because \sqrt{u^2 + 2gH} = -u + gt$ (taking downward = + ve upward = – ve)

$\therefore t = \frac{u + \sqrt{u^2 + 2gH}}{g}$ --------(i)

As we know, time taken to reach the highest point

$t = \frac{u}{g}$ ...(ii)

Now, from equation (i) and (ii)

$\frac{u + \sqrt{u^2 + 2gH}}{g} = \frac{u}{g}$ but in question the time taken by the particle to hit the ground is 'n' times that taken by it to reach the highest point of its path.

So, $\frac{u + \sqrt{u^2 + 2gH}}{g} = n \times \frac{u}{g}$

or $\sqrt{u^2 + 2gH} = u(n-1)$

$u^2 + 2gH = u^2(n-1)^2$ ...(iii)

On solving above equation (iii)

$2gH = nu^2(n-2)$

817. A body is thrown vertically up with a velocity v. It passes three points A, B and C in its upward journey with velocities $\frac{u}{2}, \frac{u}{3}$ and $\frac{u}{4}$ respectively. The ratio of the separations between points A and B and between B and C i.e., $\frac{AB}{BC}$ is

(a) 1
(b) 2
(c) $\frac{10}{7}$
(d) $\frac{20}{7}$

AMU-2009

Ans. (d) : Given data,

Initial velocity = u

Velocity at point A, $u_A = \frac{u}{2}$

Velocity at point B, $u_B = \frac{u}{3}$

Velocity at point C, $u_C = \frac{u}{4}$

$\therefore$ For distance AB, $v^2 = u^2 + 2as$

$$\left(\frac{u}{3}\right)^2 = \left(\frac{u}{2}\right)^2 + 2(-g)S_{AB}$$

$$S_{AB} = \frac{5u^2}{72g}$$

Similarly, for BC distance,

$$\left(\frac{u}{4}\right)^2 = \left(\frac{u}{3}\right)^2 + 2(-g)S_{BC}$$

$$S_{BC} = \frac{7u^2}{288g}$$

@apna_pdf

So,

$$\frac{S_{AB}}{S_{BC}} = \frac{20}{7}$$

Hence, option (d) is correct

818. A particle is thrown vertically up with an initial velocity 9 m/s from the surface of Earth (take g = 10 m/s^2). The time taken by the particle to reach a height of 4 m from the surface time (in seconds) is

(a) 1.3
(b) 1.2
(c) 1.1
(d) 1.0

AMU-2012

Ans. (d) : Given data,

$u = 9m/s$
$h = 4m$
$g = 10\ m/s^2$

We know that,
Time taken by the particle to reach a height h from the surface of earth is obtained from

$$h = ut - \frac{1}{2}gt^2 \Rightarrow 4 = 9t - \frac{1}{2}\times 10\times t^2$$

$$4 = 9t - 5t^2$$

$$5t^2 - 9t + 4 = 0 \Rightarrow 5t^2 - 5t - 4t + 4 = 0$$

$$5t(t-1) - 4(t-1) = 0$$

$$(5t-4)(t-1) = 0$$

$$\therefore \quad t = 1s \text{ or } t = \frac{4}{5}s$$

Hence, the time taken by the particle to reach a height of 4m from the surface is 1sec.

819. A body is thrown vertically upwards and then falls back on the ground. Its potential energy is maximum

(a) on the ground
(b) at the maximum height
(c) during the return journey
(d) both on the ground and at the maximum height

NDA (I) 2010

Ans. (b) : As we know that

Gravitational P.E. = mgh

$$P.E. \propto h$$

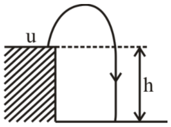
As well as height increases
Potential energy is increases
So, P.E. is max. at max height

820. A stone is thrown with an initial speed of 4.9 m/s from a bridge in vertically upward direction. It falls down in water after 2 sec. The height of bridge is

(a) 24.7m
(b) 19.8 m
(c) 9.8 m
(d) 4.9 m

JIPMER-2004

Ans. (c) : Given data,
$u = 4.9\ ms^{-1}$
$t = 2$ sec



For height (h) of bridge we have , height (h) is also the total displacement of motion

$$h = ut + \frac{1}{2}gt^2 \qquad \text{(here g = gravitational constant)}$$

$$= 4.9 \times 2 - \frac{1}{2} \times 9.8 \times 2^2$$

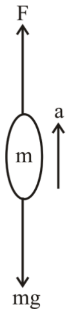
$$= 9.8 - 19.6 = 9.8 \text{ (Downward)}$$

821. A balloon of mass 10 kg is raising up with an acceleration of 20 ms^{-2}. If a mass of 4 kg is removed from the balloon its acceleration becomes (take g = 10ms^{-2})

(a) 40 ms^{-2}
(b) 20 ms^{-2}
(c) 30 ms^{-2}
(d) 12 ms^{-2}

AP EAMCET(Medical)-2015

Ans. (a) : For the motion of balloon, upward force is F then



$$F - mg = ma$$

$$F - 10 \times 10 = 10 \times 20$$

$$F - 100 = 200 \Rightarrow F = 300\ N$$

When 4 kg mass is removed then weight of balloons,

$$m'a' = F - m'g$$

Divide by m' both side,

$$a' = \frac{F}{m'} - g \qquad [\because\ m' = 10 - 4 = 6\ kg]$$

$$a' = \frac{300}{6} - 10 = 40\,m/s^2$$

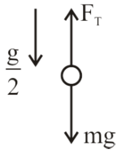
822. The mass of a balloon with its contents is 1.5 kg. It is descending with an acceleration equal to half that of acceleration due to gravity. If it is to go up with the same acceleration keeping the volume same, its mass should be decreased by

(a) 1.2 kg
(b) 1 kg
(c) 0.75 kg
(d) 0.5 kg

EAMCET-1999

Ans. (b) : Given,
Mass of balloon (m) = 1.5 kg

Acceleration of balloon = $\frac{g}{2}$

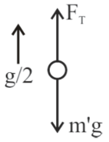


Net force acting on the balloon

$$\frac{mg}{2} = mg - F_T$$

@apna_pdf

$$F_T = \frac{mg}{2} = \frac{1.5g}{2} \qquad \text{….. (i)}$$



Let m' be the new mass of balloon

Net force on balloon, $\frac{m'g}{2} = F_T - m'g$ (upward)

$$\frac{3}{2}m'g = F_T \qquad \text{…..(ii)}$$

From equation (i) and (ii)

$$\frac{3}{2}m'g = \frac{1.5g}{2}$$

m' = 0.5 kg

Mass should be decreased by

= m – m' = 1.5 – 0.5 = 1 kg

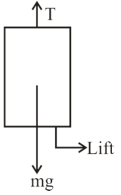
823. The mass of the lift is 100 kg which is hanging on the string. The tension in the string, when the lift is moving with constant velocity, is (g = 9.8 m/sec^2)

(a) 100 Newton (b) 980 Newton

(c) 1000 Newton (d) None of these

BITSAT-2008

Ans. (b) : Given, m = 100 kg, g = 9.8 m/s^2



If velocity is constant then,

a = 0

Now, tension develop in string is

T = mg + ma

∴ T = mg = 100×9.8 = 980 N

824. The mass of a lift is 500 kg. When it ascends with an acceleration of 2 m/s^2, the tension in the cable will be : (g = 10 m/s^2)

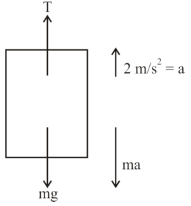
(a) 6000 N (b) 5000 N

(c) 4000 N (d) 1000 N

JCECE-2006

Ans. (a): Given that, m = 500kg, a = 2 m/s^2, g = 10 m/s^2

From the free body diagram of cable-



We know that,

$$T = ma + mg$$
$$T = 500(2+10)$$
$$T = 6000 \text{ N}$$

825. A body of mass 0.05 kg is observed to fall with an acceleration of 9.5 ms^{-2}. The opposing force of air on the body is (g = 9.8 ms^{-2}) :

(a) 0.015 N (b) 0.15 N

(c) 0.030 N (d) zero

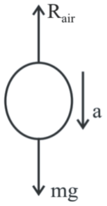
Karnataka CET-2009

Ans. (a) : Given that,

m = 0.05 kg

a = 9.5 m/s^2

g = 9.8 m/s^2



We know that,

$mg - R_{air} = ma$

$R_{air} = m(g-a)$

$= 0.05\,(9.8-9.5) = 0.015\text{N}$

(f) Motion in Incline Plane

826. Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t$_1$. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t$_2$. The time taken by her to walk up on the moving escalator

(a) $\frac{t_1+t_2}{2}$ (b) $\frac{t_1t_2}{t_1-t_2}$

(c) $\frac{t_1t_2}{t_1+t_2}$ (d) t_1+t_2

JEE Main 20.07.2021,Shift-II
[NEET 2017]

Ans. (c) : Let the height of metro station be = x

Time taken by Preeti to travel upto the stationary escalator = t$_1$

So, speed of Preeti = $\frac{x}{t_1}$

Time taken when Preeti stands on the moving escalator = t$_2$

So, speed of the escalator = $\frac{x}{t_2}$

$$\therefore \quad \text{The net speed} = \frac{x}{t_1} + \frac{x}{t_2} = \frac{xt_2 + xt_1}{t_1 \times t_2}$$
$$= \frac{x(t_1+t_2)}{t_1 \times t_2}$$

$$\text{Since, the time (taken)} = \frac{x}{\frac{x(t_1+t_2)}{t_1.t_2}} = \frac{t_1.t_2}{t_1+t_2}$$

@apna_pdf

827. Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t_1. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2 . The time taken by her to walk up on the moving escalator

(a) $\frac{t_1+t_2}{2}$ (b) $\frac{t_1t_2}{t_1-t_2}$

(c) $\frac{t_1t_2}{t_1+t_2}$ (d) t_1+t_2

JEE Main 20.07.2021,Shift-II
[NEET 2017]

Ans. (c) : Let the height of metro station be = x

Time taken by Preeti to travel upto the stationary escalator = t_1

So, speed of Preeti = $\frac{x}{t_1}$

Time taken when Preeti stands on the moving escalator = t_2

So, speed of the escalator = $\frac{x}{t_2}$

$$\therefore \quad \text{The net speed} = \frac{x}{t_1}+\frac{x}{t_2}=\frac{xt_2+xt_1}{t_1\times t_2}$$

$$= \frac{x(t_1+t_2)}{t_1\times t_2}$$

$$\text{Since, the time (taken)} = \frac{x}{\frac{x(t_1+t_2)}{t_1.t_2}} = \frac{t_1.t_2}{t_1+t_2}$$

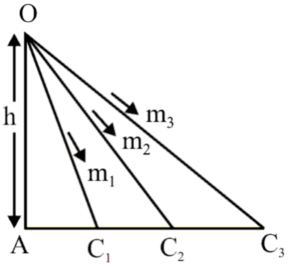
828. Three different objects m_1, m_2 and m_3 are allowed to fall from rest and from the same point O along three different frictionless paths. The speeds of the three objects, on reaching the ground, will be in the ratio of

(a) $m_1 : m_2 : m_3$ (b) 1 : 1 : 1

(c) $m_1 : 2m_2 : 3m_3$ (d) $\frac{1}{m_1}:\frac{1}{m_2}:\frac{1}{m_3}$

AIIMS-2002
AIPMT-1995

Ans. (b) :



For paths OC_1, OC_2 & OC_3 the height is same that is h.

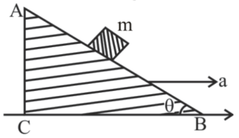
The terminal velocity be v then for all cases, $v=\sqrt{2gh}$

i.e. velocity is independent of time.

So, all will have same value of terminal velocity.

Ratio of velocity of $V_1 : V_2 : V_3 = 1 : 1 : 1$

829. A block of mass m is placed on a smooth inclined wedge ABC of inclination θ as shown in the figure. The wedge is given an acceleration 'a' towards the right. The relation between a and θ for the block to remain stationary on the wedge is

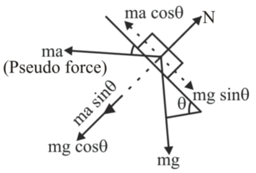


(a) $a=\frac{g}{\text{cosec}\,\theta}$ (b) $a=\frac{g}{\sin\theta}$

(c) $a = g\tan\theta$ (d) $a = g\cos\theta$

BITSAT-2013
Manipur UGET-2016

Ans. (c) :

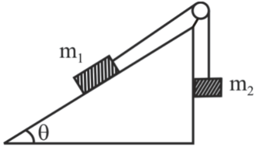


Since the frame is non-initial frame applying Newton's second law of motion

$$\therefore \quad ma\cos\theta = mg\sin\theta$$

$$a = g\tan\theta$$

830. Two bodies of masses m_1 = 5 kg and m_2 = 3 kg are connected by a light string going over a smooth light pulley on a smooth inclined plane as shown in the figure. The system is at rest. The force exerted by the inclined plane on the body of mass m_1 will be:[take $g = 10ms^{-2}$]

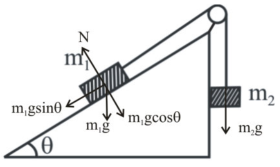


(a) 30 N (b) 40 N

(c) 50 N (d) 60 N

JEE Main-29.07.2022, Shift-II

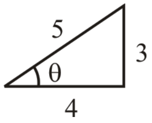
Ans. (b) : Free body diagram,



For equilibrium, $m_2g = m_1g\sin\theta$

$$\sin\theta = \frac{m_2}{m_1}=\frac{3}{5}$$

$$\cos\theta = \frac{4}{5}$$

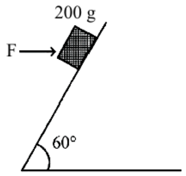


Therefore, normal force on $m_1 = 5g\cos\theta$

$$= 5\times 10\times\frac{4}{5} = 40\text{ N.}$$

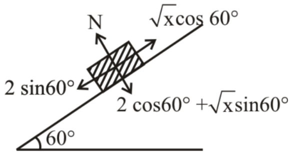
@apna_pdf

831. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}\,N$ as shown in figure. The value of x = ___________.



JEE Main-25.06.2022, Shift-II

Ans. (12.00) : According to the question figure

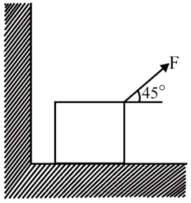


From the diagram, mg = 2N

$$\sqrt{x}\cdot\frac{1}{2}=\frac{2\sqrt{3}}{2}$$

x = 12

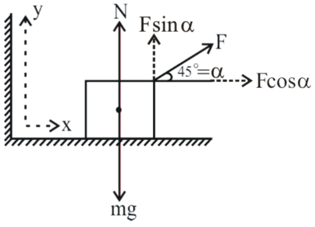
832. At the moment t = 0. a time dependent force F = at (where a is constant equal to $1Ns^{-1}$) is applied to a body of mass 1 kg resting on a smooth horizontal plane as shown in the figure. If the direction of this force makes am angle 45^0 with the horizontal. Then the velocity of the body at the moment it leaves the plane is (Acceleration due to gravity = $10m\ s^{-2}$)



(a) $50ms^{-1}$
(b) $50\sqrt{2}ms^{-1}$
(c) $50\sqrt{2}ms^{-1}$
(d) $100\sqrt{2}ms^{-1}$

AP EAMCET-05.07.2022, Shift-II

Ans. (c) : From the given figure,
Let block leaves the plane
at t = t_0 i.e N = 0 (When it leaves the plane)



So, form the F.B.D of given figure

$N = mg - F\sin\alpha = 0$

or $N = mg - at\sin\alpha = 0$ [∵ F = at (given)]

At $t = t_0$ $mg - at_0\sin\alpha = 0$

or $$t_0 = \frac{mg}{a\sin\alpha} \quad \text{....(i)}$$

From $F_x = mv_x$, to the body under horizontal direction:

$$\frac{mdv_x}{dt} = at\cos\alpha$$

Integrating within limit for v(t)

$$m\int_0^v dv_x = a\cos\alpha\int_0^t tdt \quad \text{[Using eq}^n\text{ (i)]}$$

$$\text{so, } v_x = \frac{a\cos\alpha}{2m}t^2 \quad \text{......(ii)}$$

it leaves at t = t_0 we get $v = \frac{a\cos\alpha}{2m}t_0^2$

Put the value of t_0 from eq^n (i) we get

$$v = \frac{mg^2\cos\alpha}{2a\sin^2\alpha}$$

After putting the value we get,

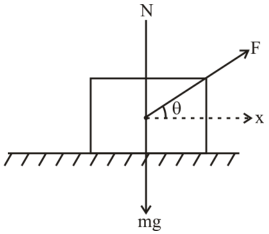
$$v = \frac{1\times10^2\times\cos45°}{2\times1\times\sin^2 45°} = 50\sqrt{2}\ ms^{-1}$$

833. A bar of mass m resting on a smooth horizontal plane starts moving due to a constant force F. In the process of its rectilinear motion the angle θ between the direction of this force and the horizontal varies as θ = kx, where k is a constant and x is the distance traversed by the bar from its initial position. The velocity (v) of the bar as a function of the angle θ is

(a) $v = \sqrt{\frac{2F\sin\theta}{mk}}$
(b) $v = \sqrt{\frac{2F}{mk\sin\theta}}$
(c) $v = \frac{2F\sin\theta}{mk}$
(d) $v = \frac{2F}{mk\sin\theta}$

AP EAMCET-07.07.2022, Shift-I

Ans. (a) :



Newton's 2^{nd} law of motion, along with horizontal,
$F_x = mw_x$

$$F\cos\theta = mv\frac{dv}{dx}$$

$$F\cos\theta.dx = mvdv$$

Integrating, both side,

$$\int\frac{F}{m}\cos\theta dx = \int vdv$$

$$\frac{F}{m}\int\cos\theta.dx = \frac{v^2}{2}$$

$$\frac{F}{m}\int\cos(kx).dx = \frac{v^2}{2} \quad [\because\ \theta = kx]$$

$$v = \sqrt{\frac{2F\sin\theta}{mk}}$$

@apna_pdf

834. **A small block slides down on a smooth inclined plane, starting from rest at time t = 0. Let S_n be the distance travelled by the block in the interval t = n −1 to t = n. Then, the ratio $\frac{S_n}{S_{n+1}}$ is**

(a) $\frac{2n-1}{2n}$ (b) $\frac{2n-1}{2n+1}$

(c) $\frac{2n+1}{2n-1}$ (d) $\frac{2n}{2n-1}$

[NEET 2021]

Ans. (b) : S_n = Distance in nth sec.

∴ t = n – 1 to t = n

S_{n+1} = Distance in (n + 1)th sec

i.e. t = n to t = n + 1

We know that,

$$S_n = 0 + \frac{a}{2}(2n-1)$$

Or $S_n = \frac{a}{2}(2n-1)$ ....(i)

and, $S_{(n+1)} = 0 + \frac{a}{2}[2(n+1)-1]$

Or $S_{(n+1)} = \frac{a}{2}[2(n+1)-1]$ ...(ii)

From equation (i) & (ii),

Hence, $\frac{S_n}{S_{(n+1)}} = \frac{\frac{a}{2}(2n-1)}{\frac{a}{2}[2(n+1)-1]} = \frac{2n-1}{2n+1}$

835. **A small block slides down on a smooth inclined plane, starting from rest at time t = 0. Let S_n be the distance travelled by the block in the interval t = n −1 to t = n. Then, the ratio $\frac{S_n}{S_{n+1}}$ is**

(a) $\frac{2n-1}{2n}$ (b) $\frac{2n-1}{2n+1}$

(c) $\frac{2n+1}{2n-1}$ (d) $\frac{2n}{2n-1}$

[NEET 2021]

Ans. (b) : S_n = Distance in nth sec.

∴ t = n – 1 to t = n

S_{n+1} = Distance in (n + 1)th sec

i.e. t = n to t = n + 1

We know that,

$S_n = 0 + \frac{a}{2}(2n-1)$ Or $S_n = \frac{a}{2}(2n-1)$ ....(i)

and, $S_{(n+1)} = 0 + \frac{a}{2}[2(n+1)-1]$

Or $S_{(n+1)} = \frac{a}{2}[2(n+1)-1]$ ...(ii)

From equation (i) & (ii),

Hence, $\frac{S_n}{S_{(n+1)}} = \frac{\frac{a}{2}(2n-1)}{\frac{a}{2}[2(n+1)-1]} = \frac{2n-1}{2n+1}$

836. **When an object is shot from the bottom of a long smooth inclined plane kept at an angle 60° with horizontal, it can travel a distance x_1 along the plane. But when the inclination is decreased to 30° and the same object is shot with the same velocity, it can travel x_2 distance. Then x_1: x_2 will be**

(a) $\sqrt{2}:1$ (b) $1:\sqrt{3}$

(c) $1:2\sqrt{3}$ (d) $1:\sqrt{2}$

[NEET (National) 2019]

Ans. (b) : From the third equation of motion –

$v^2 = u^2 - 2as$

Acceleration along the plane is a = g sinθ

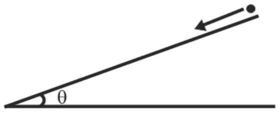
∴ $s = \frac{u^2}{2g\sin\theta}$ (v = 0)

$x_1 = \frac{u^2}{2g\sin 60°}$ ...(i)

$x_2 = \frac{u^2}{2g\sin 30°}$ ....(ii)

So, $\frac{x_1}{x_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{\sin 30°}{\sin 60°} = \frac{1}{\sqrt{3}}$

837. **A ball is released from rest and rolls down an inclined plane, as shown in the following figure, requiring 4s to cover a distance of 100 cm along the plane:**



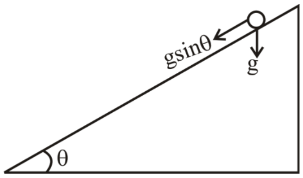
Which one of the following is the correct value of angle θ that the plane makes with the horizontal? (g = 1000 cm/s^2)

(a) $\theta = \sin^{-1}(1/9.8)$ (b) $\theta = \sin^{-1}(1/20)$

(c) $\theta = \sin^{-1}(1/80)$ (d) $\theta = \sin^{-1}(1/100)$

NDA (II) 2018

Ans. (c) : According to question,



- Ball start from rest, u = 0
- Ball cover a 100 m distance in 4 sec.

@apna_pdf

- Effective acceleration in direction of motion of ball.

$a = g \sin\theta$

From, $s = ut + 1/2\, at^2$

$100 = 0 + 1/2 \times g\sin\theta \times t^2$

$100 = 1/2 \times 1000 \times \sin\theta \times 16$

$\sin\theta = 1/80$

$\theta = \sin^{-1}(1/80)$

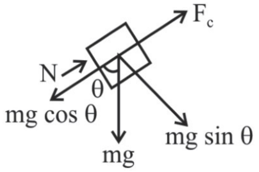
838. An object is placed at the top of a frictionless hemispherical metallic surface of radius 3m. If the object is just disturbed, it will slide down and leaves the hemispherical surface at a height of

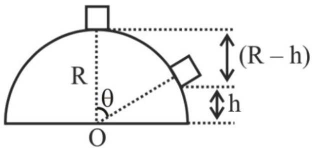
(a) 1m (b) 2m

(c) 3m (d) 4m

AP EAMCET-28.04.2017, Shift-I

Ans. (b) :





$F_c + N = mg\cos\theta$ (N = 0)

$\frac{mv^2}{R} = mg\cos\theta$

$v^2 = Rg\cos\theta$ $\left(\cos\theta = \frac{h}{R}\right)$

$v^2 = R \times g \times \frac{h}{R}$

$v^2 = gh$ …………..(i)

Now,

$mg(R-h) = \frac{1}{2}mv^2$

$v^2 = 2g(R-h)$ ………..(ii)

From equation (i) and (ii) we get,

$gh = 2g(R-h)$

$h = 2R - 2h$

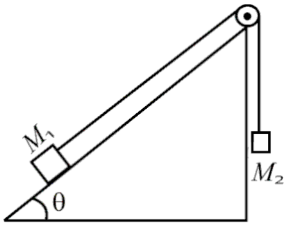
$3h = 2R$

$h = \frac{2R}{3}$ (given R = 3 m)

$h = 2 \times \frac{3}{3}$

$h = 2$ m

839. Two masses M_1 and M_2 are attached to the ends of a string which passes over a pulley attached to the top of an inclined plane. The angle of inclination of the plane is 30° and M_1 = 10 kg, M_2 = 5 kg. What is the acceleration of mass M_2?



(a) 10 m/s^2 (b) 5 m/s^2

(c) $\frac{2}{3}$ m/s^2 (d) zero

J&K CET- 2000

Ans. (d) : Given,

$\theta = 30°$

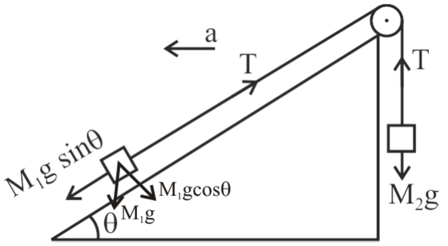
$M_1 = 10\,kg$

$M_2 = 5\,kg$

$M_1 g\sin\theta - T = M_1 a$ ……. (i)

$T - M_2 g = M_2 a$ …….. (ii)

From equation (i) and (ii)



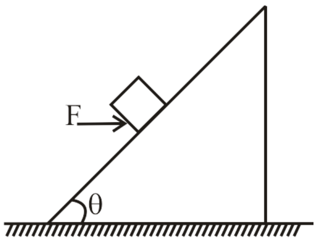
$M_1 g\sin\theta - M_2 g = (M_1 + M_2)a$

$10 \times 10 \times \frac{1}{2} - 5 \times 10 = (10+5)a$

$0 = 15\,a$

$a = 0\ m/s^2$

840. A horizontal force F is applied to a block of mass m on a smooth fixed inclined plane of inclination θ to the horizontal as shown in the figure. Resultant force on the block up the plane is



(a) F cos θ – mg sin θ

(b) F sin θ + mg cos θ

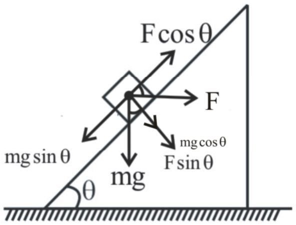
(c) F sin θ – mg cos θ

(d) F cos θ + mg sin θ

AP EAMCET(Medical)-2014

@apna_pdf

Ans. (a) : According to question,



Gravitational force acts on the block in downward direction.

Resultant upward force (F') = Fcosθ – mgsinθ

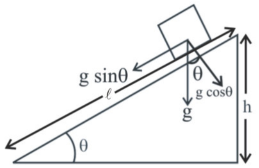
841. A body is slipping from an inclined plane of height h and length ℓ, angle of inclination is θ, the time taken by the body to come from the top to the bottom of this inclined plane is

(a) $\sqrt{\frac{2\ell}{g}}$ (b) $\sin\theta\sqrt{\frac{2h}{g}}$

(c) $\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$ (d) $\sqrt{\frac{2h}{g}}$

UP CPMT-2011

Ans. (c) : From the given figure,



$$\sin\theta = \frac{h}{\ell} \Rightarrow \ell = \frac{h}{\sin\theta} \quad ......(i)$$

$$\because \quad s = ut + \frac{1}{2}(g\sin\theta)t^2$$

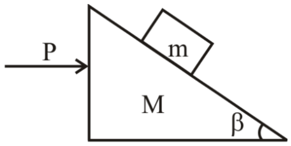
$$\ell = ut + \frac{1}{2}(g\sin\theta)t^2$$

$$\ell = 0 + \frac{1}{2}(g\sin\theta)t^2 \qquad (\because u = 0)$$

$$\frac{h}{\sin\theta} = \frac{1}{2}(g\sin\theta)t^2$$

$$t^2 = \frac{2h}{g\sin^2\theta} \Rightarrow t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$$

842. Two wooden blocks are moving on a smooth horizontal surface such that the block having mass m remains stationary with respect to block of mass M as shown in the figure below. The magnitude of the applied force P is

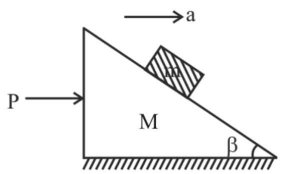


(a) g tan β (b) mg cosβ

(c) (M + m) cosec β (d) (M + m) g tan β

Assam CEE-2016

Ans. (d) :



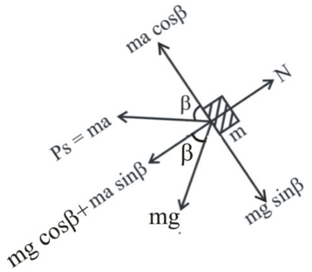
(M+m) is a system of masses and having accelerating a.

We know that,

Force (F) = ma

P = (M + m)a ....(i)

∵ N = mg cosβ + ma sinβ



Balance equation:-

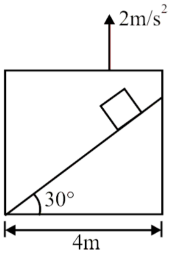
ma cosβ = mg sin β

a = g tanβ

Putting value of a in equation (1)

P = (M + m) g tan β

843. A particle slides down on a smooth incline of inclination 30°, fixed in an elevator going up with an acceleration 2 m/s². The box of incline has a length 4m. The time taken by the particle to reach the bottom will be

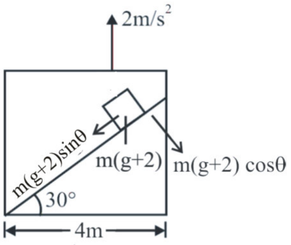


(a) $\frac{8}{3}\sqrt{3}\,s$ (b) $\frac{9}{8}\sqrt{3}\,s$

(c) $\frac{4}{3}\sqrt{\frac{\sqrt{3}}{2}}\,s$ (d) $\frac{3}{4}\sqrt{\frac{\sqrt{3}}{2}}\,s$

JIPMER-2016

Ans. (c) :



g = 10m/s²

@apna_pdf

On resolving the particle

Let particle slide distance = S

Acceleration on taking horizontal component

$$a=(g+2)\sin 30°$$

$$m(g+2)\sin 30° = ma$$

$$(10+2)\frac{1}{2}=a$$

$$a = 6\ \text{m/sec}^2$$

On taking vertical component

From figure

$$\cos 30° = \frac{4}{S}$$

$$S=\frac{4}{\sqrt{3/2}}=8/\sqrt{3}=\frac{8\sqrt{3}}{3}$$

Distance

$$S=ut+\tfrac{1}{2}at^2$$

$$S=\frac{1}{2}at^2 \qquad (u=0)$$

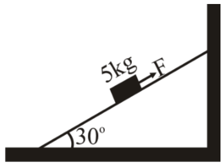
$$t^2=\frac{2S}{a}$$

$$t=\sqrt{\frac{2S}{a}}=\sqrt{\frac{2\times 8\sqrt{3}}{3\times 6}}$$

$$t=\frac{4}{3}\sqrt{\frac{\sqrt{3}}{2}}\ \text{sec.}$$

844. A force F = 75 N is applied on a block of mass 5 kg along the fixed smooth incline as shown in figure. Here gravitational acceleration g = 10 m/s^2.

The acceleration of the block is



(a) $10\frac{m}{s^2}$ downwards the incline

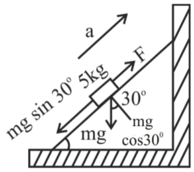
(b) $10\frac{m}{s^2}$ upwards the incline

(c) $5\frac{m}{s^2}$ downwards the incline

(d) $5\frac{m}{s^2}$ upwards the incline

UPSEE - 2016

Ans. (b) : Given,



Given,

F = 75 N, m = 5 kg

Acceleration of the block,

F – mg sin 30° = m.a

$$a=\frac{F-mg\sin 30°}{m}$$

$$a=\frac{75-5g\sin 30°}{5}$$

$$a=\frac{50}{5}=10\ \text{m/s}^2 \text{ upward to the inclined plane.}$$

845. A block at rest slides down a smooth inclined plane which makes an angle 60° with the vertical and it reaches the ground in t_1 seconds. Another block is dropped vertically from the same point and reaches the ground in t_2 seconds. Then the ratio of $t_1 : t_2$ is

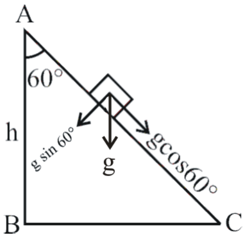
(a) 1 : 2 (b) 2 : 1

(c) 1 : 3 (d) $1:\sqrt{2}$

(e) 3 : 1

Kerala CEE - 2011

Ans. (b) :



In Δ ABC

$$\cos 60° = \frac{AB}{AC}$$

$$\frac{1}{2}=\frac{AB}{AC}$$

AC = 2AB = 2h

From second equation of motion

$$s=ut+\frac{1}{2}at^2,\ u=0$$

$$\therefore \qquad h=\frac{1}{2}gt_2^2 \qquad ....(i)$$

$$2h=ut_1+\frac{1}{2}g\cos 60\times t_1^2 \quad [\because a=g\cos 60°]$$

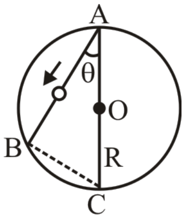
$$2h=\frac{1}{2}\times g\times\frac{1}{2}\times t_1^2 \qquad ....(ii)$$

From equation (i) and (ii)

$$t_1 : t_2 = 2 : 1$$

846. A frictionless wire AB is fixed on a sphere of radius R. A very small spherical ball slips on this wire. The time taken by this ball to slip from A to B is

@apna_pdf



(a) $\dfrac{\sqrt{2gR}}{g\cos\theta}$

(b) $2\sqrt{gR}\dfrac{\cos\theta}{g}$

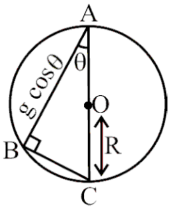
(c) $2\sqrt{\dfrac{R}{g}}$

(d) $\dfrac{gR}{\sqrt{g\cos\theta}}$

BITSAT-2016

Ans. (c) : Acceleration of body along AB i.e. a_{AB} = g cosθ

Distance travelled in time't' sec



$$AB = \frac{1}{2}a_{AB}t^2$$

$$AB = \frac{1}{2}(g\cos\theta)t^2 ....(i)$$

From ΔABC,

$$\cos\theta = \frac{AB}{AC} \qquad [\because AC = 2R]$$

AB = 2R cosθ

Putting the value of AB in eq^n (i)

$$2R\cos\theta = \frac{1}{2}g\cos\theta\, t^2$$

$$t^2 = \frac{4R}{g}$$

$$t = 2\sqrt{\frac{R}{g}}$$

847. An object is placed on a smooth inclined plane of 1 in *l*. The horizontal acceleration to be imparted to inclined plane so that, the object is stationary relative to the inclined is given by

(a) $\dfrac{g}{l^2-1}$

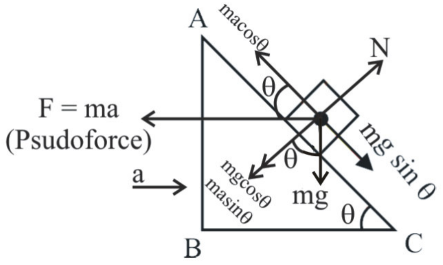
(b) $\dfrac{g}{\sqrt{l^2-1}}$

(c) $g\sqrt{l^2-1}$

(d) $g(l^2-1)$

UPSEE - 2015

Ans. (b) :



Given,

AB = 1, AC = *l*

So,

$$\text{that } BC = \sqrt{(AC)^2 - (AB)^2}$$

$$= \sqrt{(l)^2 - (1)^2}$$

$$= \sqrt{l^2 - 1}$$

$$\text{Thus, } \tan\theta = \frac{AB}{BC} = \frac{1}{\sqrt{l^2-1}}$$

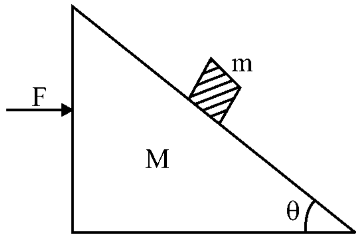
A horizontal acceleration a imparted to the inclined plane has a component a cosθ down the plane. If this equals the component g sinθ along the plane, the object will appear stationary relative to the incline .

ma cosθ = mg sinθ

$$a = \frac{g\sin\theta}{\cos\theta}$$

$$a = g\tan\theta = \frac{g}{\sqrt{l^2-1}}$$

848. A mass m is placed on a wedge (triangular block) of mass M. The wedge moves on a smooth horizontal surface what should be the force F applied on the wedge to the right. so that m remains stationary with respect to wedge. (Ignore any friction)



(a) g tanθ

(b) mg cos θ

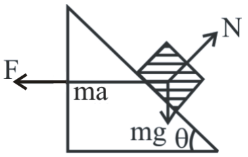
(c) (M + m) g tanθ

(d) (M + m) g cosecθ

Manipal UGET-2016

@apna_pdf

Ans. (c) :



From figure, mg sinθ = ma cosθ

$$\frac{\sin\theta}{\cos\theta}=\frac{ma}{mg}$$

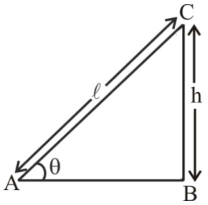
$$\tan\theta=\frac{a}{g}$$

$$a = g\tan\theta$$

∴ Force, F = (M + m)a

F = (M + m) g tanθ

849. A smooth inclined plane is inclined at an angle θ with horizontal. A body starts from rest and slides down the inclined surface.



Then the time taken by it to reach the bottom is

(a) $\sqrt{\left(\frac{2h}{g}\right)}$

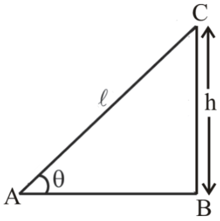
(b) $\sqrt{\left(\frac{2\ell}{g}\right)}$

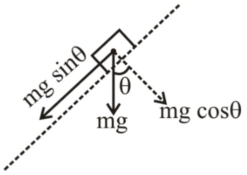
(c) $\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$

(d) $\sin\theta\frac{\sqrt{(2h)}}{g}$

AIIMS-2015

Ans. (c) : Given, the initial velocity of body will be zero because body moves from rest i.e. u = 0





According to second law of motion-

$$s = ut+\frac{1}{2}\,a\,t^2$$

Here, $s = l$, $a = g\sin\theta$

$$\therefore \quad l = 0\times t+\frac{1}{2}(g\sin\theta)\times t^2$$

$$t=\sqrt{\frac{2l}{g\sin\theta}} \qquad \text{...(i)}$$

In ΔBAC -

$$\sin\theta=\frac{h}{l}$$

$$l=\frac{h}{\sin\theta}$$

Putting the value of l in equation (i), we get-

$$t=\sqrt{\frac{\frac{2\times h}{\sin\theta}}{g\sin\theta}}$$

or $$t=\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$$

850. A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally, so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be

(a) mg cosθ

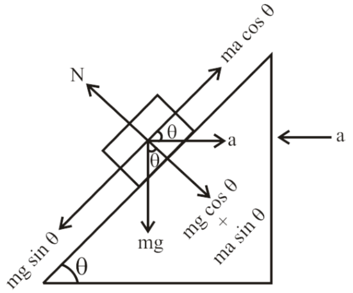
(b) mg sinθ

(c) mg

(d) $\frac{mg}{\cos\theta}$

AIPMT- 2004

Ans. (d) : Given, mass = m, angle = θ



According to diagram,

mg sin θ = ma cos θ (along the inclined plane)

$$a=\frac{g\sin\theta}{\cos\theta}$$

$$a = g\tan\theta$$

Hence,

Total reaction of the wedge on the block is

$$N = mg\cos\theta + ma\sin\theta$$

$$N = mg\cos\theta+\frac{mg\sin\theta\,.\,\sin\theta}{\cos\theta}$$

$$N=\frac{mg(\cos^2\theta+\sin^2\theta)}{\cos\theta} \qquad [\because \cos^2\theta+\sin^2\theta=1]$$

$$N=\frac{mg}{\cos\theta}$$

@apna_pdf

03. Motion in Plane

(a) Scalar and Vector Quantity

1. A small particle moves to position $5\hat{i}-2\hat{j}+\hat{k}$ from its initial position $2\hat{i}+3\hat{j}-4\hat{k}$ under the action of force $5\hat{i}+2\hat{j}+7\hat{k}$ N. The value of work done will be ____________J.

JEE Main-01.02.2023, Shift-I

Ans. (40) : Given,

Initial position ($\vec{r}_1$)= $2\hat{i}+3\hat{j}-4\hat{k}$

Final position ($\vec{r}_2$)= $5\hat{i}-2\hat{j}+\hat{k}$

Force = $5\hat{i}+2\hat{j}+7\hat{k}$

We know that,

Work done (W)= Force . displacement

$$W=\vec{F}.\vec{r}$$

Here $\vec{r}=\vec{r}_2-\vec{r}_1$

$$\vec{r}=(5\hat{i}-2\hat{j}+\hat{k})-(2\hat{i}+3\hat{j}-4\hat{k})$$

$$\vec{r}=(5-2)\hat{i}+(-2-3)\hat{j}+(1-(-4))\hat{k}$$

$$\vec{r}=3\hat{i}-5\hat{j}+5\hat{k}$$

Work done = $\vec{F}.\vec{r}=\left(5\hat{i}+2\hat{j}+7\hat{k}\right).\left(3\hat{i}-5\hat{j}+5\hat{k}\right)$

$= (15 - 10 + 35)$ J

Work done = 40 J

2. Vectors $a\hat{i}+b\hat{j}+\hat{k}$ and $2\hat{i}-3\hat{j}+4\hat{k}$ are perpendicular to each other when 3a + 2b = 7, the ratio of a and b is $\frac{x}{2}$ The value of x is______.

JEE Main-24.01.2023, Shift-I

Ans. (1) : Let $\vec{A}=a\hat{i}+b\hat{j}+\hat{k}$ and $\vec{B}=2\hat{i}-3\hat{j}+4\hat{k}$

Given, $\vec{A}\perp\vec{B}$

Such that, $\vec{A}.\vec{B}=0$

$$\left(a\hat{i}+b\hat{j}+\hat{k}\right).\left(2\hat{i}-3\hat{j}+4\hat{k}\right)=0$$

$2a - 3b + 4 = 0$

$2a - 3b = -4$ ….(i)

and, $3a + 2b = 7$ ….(ii)

After solving we get,

a = 1 and b = 2

$$\frac{a}{b}=\frac{1}{2}$$

Hence, value of x = 1

3. If two vectors $\vec{P}=\hat{i}+2m\hat{j}+m\hat{k}$ and $\vec{Q}=4\hat{i}-2\hat{j}+m\hat{k}$ are perpendicular to each other. Then, the value of m will be:

(a) –1 (b) 2

(c) 3 (d) 1

JEE Main-24.01.2023, Shift-II

Ans. (b) : Given, $\vec{P}=\hat{i}+2m\hat{j}+m\hat{k}$

$\vec{Q}=4\hat{i}-2\hat{j}+m\hat{k}$

Two vectors $\vec{P}$ and $\vec{Q}$ are perpendicular,

$$\vec{P}\cdot\vec{Q}=0$$

$$(\hat{i}+2m\hat{j}+m\hat{k})\cdot(4\hat{i}-2\hat{j}+m\hat{k})=0$$

$4 - 4m + m^2 = 0$

$m^2 - 4m + 4 = 0$

$(m - 2)^2 = 0$

m = 2

4. If $\vec{P}=3\hat{i}+\sqrt{3}\hat{j}+2\hat{k}$ and $\vec{Q}=4\hat{i}+\sqrt{3}\hat{j}+2.5\hat{k}$ then, the unit vector in the direction of $\vec{P}\times\vec{Q}$ is $\frac{1}{x}\left(\sqrt{3}\hat{i}+\hat{j}-2\sqrt{3}\hat{k}\right)$ .The value of x is

JEE Main-25.01.2023, Shift-I

Ans. (4) : Given,

$\vec{P}=3\hat{i}+\sqrt{3}\hat{j}+2\hat{k}$

$\vec{Q}=4\hat{i}+\sqrt{3}\hat{j}+2.5\hat{k}$

From direction of unit vector is along $\vec{P}\times\vec{Q}$

Then, $$\vec{P}\times\vec{Q}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 3 & \sqrt{3} & 2\\ 4 & \sqrt{3} & \frac{5}{2}\end{vmatrix}$$

$$\vec{P}\times\vec{Q}=\hat{i}\left(\frac{5\sqrt{3}}{2}-2\sqrt{3}\right)-\hat{j}\left(\frac{15}{2}-8\right)+\hat{k}\left(3\sqrt{3}-4\sqrt{3}\right)$$

$$\vec{P}\times\vec{Q}=\frac{\sqrt{3}}{2}\hat{i}+\frac{\hat{j}}{2}-\sqrt{3}\hat{k}$$

$$\left|\vec{P}\times\vec{Q}\right|=\sqrt{\left(\frac{\sqrt{3}}{2}\right)^2+\left(\frac{1}{2}\right)^2+\left(-\sqrt{3}\right)^2}$$

$$=\sqrt{\frac{3}{4}+\frac{1}{4}+3}=2$$

Unit vector $=\dfrac{\vec{P}\times\vec{Q}}{\left|\vec{P}\times\vec{Q}\right|}$

@apna_pdf

$$=\frac{\frac{\sqrt{3}}{2}\hat{i}+\frac{1}{2}\hat{j}-\sqrt{3}\hat{k}}{2}$$

$$=\frac{1}{4}\left(\sqrt{3}\hat{i}+\hat{j}-2\sqrt{3}\hat{k}\right)$$

According to question, unit vector $\frac{1}{x}\left(\sqrt{3}\hat{i}+\hat{j}-2\sqrt{3}\hat{k}\right)$

Hence, value of x = 4

5. If $\vec{A}, \vec{B}$ are perpendicular vectors

$\vec{A} = 5\hat{i}+7\hat{j}-3\hat{k}$

$\vec{B} = 2\hat{i}+2\hat{j}-c\hat{k}$.

The value of c is

(a) –2 (b) 8

(c) –7 (d) –8

EAMCET-1991

Ans. (d) : $\vec{A} = 5\hat{i}+7\hat{j}-3\hat{k}$

$\vec{B} = 2\hat{i}+2\hat{j}-c\hat{k}$

For perpendicular vectors

$\vec{A}\cdot\vec{B}=0$

$\left(5\hat{i}+7\hat{j}-3\hat{k}\right)\cdot\left(2\hat{i}+2\hat{j}-c\hat{k}\right)=0$

$10+14+3c=0$

$24=-3c$

$c=-8$

6. The resultant of the vectors A and B depends also on the angle θ between them. The magnitude of the resultant is always given by

(a) $A+B+2AB\cos\theta$

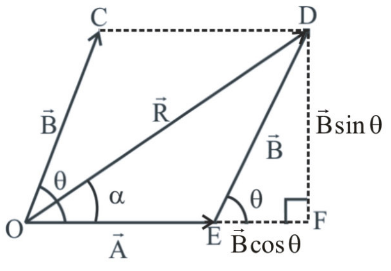
(b) $\sqrt{(A+B+2AB\cos\theta)}$

(c) $\sqrt{A^2+B^2+2AB\cos\theta}$

(d) $\left(A^2+B^2+2AB\cos\theta\right)^2$

EAMCET-1992

Ans. (c) :



Resultant vector, $\vec{R}$

From ΔDOF,

$(OD)^2 = (OF)^2 + (DF)^2$

$(OD)^2 = (OE + EF)^2 + (DF)^2$

$\vec{R}^2 = (\vec{A} + \vec{B}\cos\theta)^2 + (\vec{B}\sin\theta)^2$

$= A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$

$= A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta$

$\vec{R}^2 = A^2 + B^2 + 2AB\cos\theta$

$|\vec{R}| = \sqrt{A^2+B^2+2AB\cos\theta}$

7. $\vec{A}$ and $\vec{B}$ are vectors such that $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$. Then, the angle between them is

(a) 90º (b) 60º

(c) 45º (d) 0º

EAMCET-1993

Ans. (a) : Given,

$|\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$

Squaring both sides,

$|\vec{A}+\vec{B}|^2=|\vec{A}-\vec{B}|^2$

$\vec{A}^2+\vec{B}^2+2\vec{A}\cdot\vec{B}=\vec{A}^2+\vec{B}^2-2\vec{A}\cdot\vec{B}$

$4\vec{A}\cdot\vec{B}=0$

$\vec{A}\cdot\vec{B}=0$

$|\vec{A}||\vec{B}|\cos\theta=0$

$\cos\theta=0$

$\theta=90°$

8. When two vectors $\vec{A}$ and $\vec{B}$ of magnitude a and b are added, the magnitude of the resultant vector is always

(a) equal to (a + b)

(b) less than (a + b)

(c) greater than (a + b)

(d) not greater than (a + b)

EAMCET-1993

Ans. (d) : Given,

$|\vec{A}|=a, |\vec{B}|=b$

$|\vec{A}+\vec{B}|=\sqrt{a^2+b^2+2ab\cos\theta}$

$|\vec{A}+\vec{B}|_{max}=\sqrt{a^2+b^2+2ab}$ [For max, θ = 0]

$|\vec{A}+\vec{B}|_{max}=(a+b)$

Hence, magnitude of resultant vector is not greater than (a + b)

9. If a unit vector is represented by $0.5\hat{i}+0.8\hat{j}+c\hat{k}$, the value of c is

(a) 1 (b) $\sqrt{0.11}$

(c) $\sqrt{0.011}$ (d) $\sqrt{0.39}$

TS-EAMCET-10.09.2020, Shift-1

EAMCET-1994

Ans. (b) : $\hat{A}=0.5\hat{i}+0.8\hat{j}+c\hat{k}$

∴ $|\hat{A}|=1$

$\sqrt{0.5^2+0.8^2+c^2}=1$

$c^2=0.11$

$c=\sqrt{0.11}$

10. The angle made by the vector $\vec{A}=\hat{i}+\hat{j}$ with x-axis is

(a) 90º (b) 45º

(c) 22.5º (d) 30º

EAMCET-1996

@apna_pdf

Ans. (b) : Given that,

$$\vec{A} = \hat{i} + \hat{j}$$

$$|\vec{A}| = \sqrt{1^2 + 1^2} = \sqrt{2}$$

$$A_x = 1,\ A_y = 1$$

If θ is the angle made by the vector with x–axis than,

$$\cos\theta = \frac{A_x}{|\vec{A}|} \Rightarrow \cos\theta = \frac{1}{\sqrt{2}}$$

$$\theta = 45°$$

11. The angle between two vectors $6\hat{i} + 6\hat{j} - 3\hat{k}$ and $7\hat{i} + 4\hat{j} + 4\hat{k}$ is given by

(a) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (b) $\cos^{-1}\left(\frac{5}{\sqrt{3}}\right)$

(c) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$ (d) $\sin^{-1}\left(\frac{\sqrt{5}}{3}\right)$

EAMCET-1999

Ans. (d) : Given that,

$$\vec{A} = 6\hat{i} + 6\hat{j} - 3\hat{k}$$

$$\vec{B} = 7\hat{i} + 4\hat{j} + 4\hat{k}$$

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$$

$$\left(6\hat{i} + 6\hat{j} - 3\hat{k}\right)\cdot\left(7\hat{i} + 4\hat{j} + 4\hat{k}\right)$$

$$= \left[\sqrt{36+36+9}\cdot\sqrt{49+16+16}\right]\cos\theta$$

$$42 + 24 - 12 = \sqrt{81}\sqrt{81}.\cos\theta = 9\times 9\cos\theta$$

$$54 = 81\cos\theta$$

$$\cos\theta = \frac{54}{81}$$

$$\cos\theta = \frac{6}{9} = \frac{2}{3}$$

$$\sin^2\theta = 1 - \cos^2\theta = 1 - \left(\frac{2}{3}\right)^2$$

$$\sin^2\theta = 1 - \frac{4}{9} = \frac{5}{9}$$

$$\sin\theta = \frac{\sqrt{5}}{3}$$

$$\theta = \sin^{-1}\frac{\sqrt{5}}{3}$$

12. The component of vector $A = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$ along the direction of $\hat{i} - \hat{j}$ is

(a) $a_x - a_y + a_z$ (b) $a_x - a_y$

(c) $\left(a_x - a_y\right)/\sqrt{2}$ (d) $(a_x + a_y + a_z)$

EAMCET-2008

Ans. (c) : Given,

$$\vec{A} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

Let $\vec{B} = \hat{i} - \hat{j}$

Component of vector A along any vector B

$$= \frac{\vec{A}.\vec{B}}{|\vec{B}|}$$

Component of vector $\vec{A} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$ along $\vec{B} = \left(\hat{i} - \hat{j}\right)$

$$= \frac{\left(a_x\hat{i} + a_y\hat{j} + a_z\hat{k}\right).\left(\hat{i} - \hat{j}\right)}{\sqrt{(1)^2 + (-1)^2}} = \frac{a_x - a_y}{\sqrt{2}}$$

13. For vectors $\vec{A}$ and $\vec{B}$ making an angle θ which one of the following relations is correct?

(a) $\vec{A}\times\vec{B} = \vec{B}\times\vec{A}$ (b) $\vec{A}\times\vec{B} = AB\sin\theta$

(c) $\vec{A}\times\vec{B} = AB\cos\theta$ (d) $\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$

DCE-2009

Ans. (d) : We know that,

Cross product of vectors $\vec{A}$ and $\vec{B}$

$$\vec{A}\times\vec{B} = AB\sin\theta$$

Cross product of vectors $\vec{B}$ and $\vec{A}$

$$\vec{B}\times\vec{A} = -BA\sin\theta$$

So, $\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$

14. Given two vectors $\vec{A} = -\hat{i} + 2\hat{j} - 3\hat{k}$ and $\vec{B} = 4\hat{i} - 2\hat{j} + 6\hat{k}$. The angle made by $(\vec{A} + \vec{B})$ with x-axis is

(a) 30° (b) 45°

(c) 60° (d) 90°

AP EAMCET(Medical)-2007

Ans. (b) : $\vec{A} = -\hat{i} + 2\hat{j} - 3\hat{k}$

$$\vec{B} = 4\hat{i} - 2\hat{j} + 6\hat{k}$$

$$\vec{A} + \vec{B} = (-\hat{i} + 2\hat{j} - 3\hat{k}) + (4\hat{i} - 2\hat{j} + 6\hat{k})$$

$$\vec{A} + \vec{B} = 3\hat{i} + 0\hat{j} + 3\hat{k}$$

α is angle with x–axis

$$\cos\alpha = \frac{x - \text{component of}\left(\vec{A} + \vec{B}\right)}{|\vec{A} + \vec{B}|}$$

$$\cos\alpha = \frac{3}{\sqrt{9+0+9}} = \frac{3}{3\sqrt{2}}$$

$$\cos\alpha = \frac{1}{\sqrt{2}}$$

$$\alpha = 45^{\circ}$$

15. Of the vectors given below, the parallel vectors are,

$$\vec{A} = 6\hat{i} + 8\hat{j}$$

$$\vec{B} = 210\hat{i} + 280\hat{k}$$

$$\vec{C} = 5.1\hat{i} + 6.8\hat{j}$$

$$\vec{D} = 3.6\hat{i} + 6\hat{j} + 48\hat{k}$$

(a) $\vec{A}$ and $\vec{B}$ (b) $\vec{A}$ and $\vec{C}$

(c) $\vec{A}$ and $\vec{D}$ (d) $\vec{C}$ and $\vec{D}$

AP EAMCET(Medical)-2006

@apna_pdf

Ans. (b) : If component of vector is same then vectors will be same.

$\vec{A}=6\hat{i}+8\hat{j}$

$\vec{B}=210\hat{i}+280\hat{k}$

$\vec{C}=5.1\hat{i}+6.8\hat{j}$

$\vec{D}=3.6\hat{i}+6\hat{j}+48\hat{k}$

$\because \vec{C}=5.1\hat{i}+6.8\hat{j}=\frac{1.7}{2}\left(6\hat{i}+8\hat{j}\right)$

Hence, it is clear that $\vec{A}$ and $\vec{C}$ are parallel and we can write as, $\vec{C}=\frac{1.7}{2}\vec{A}$

This implies that A is parallel to C.

16. A vector $\vec{Q}$ which has a magnitude of 8 is added to the vector $\vec{P}$, which lies along the X-axis. The resultant of these two vectors is a third vector $\vec{R}$, which lies along the Y-axis and has a magnitude twice that of $\vec{P}$. The magnitude of $\vec{P}$ is:

(a) $\frac{6}{\sqrt{5}}$ (b) $\frac{8}{\sqrt{5}}$

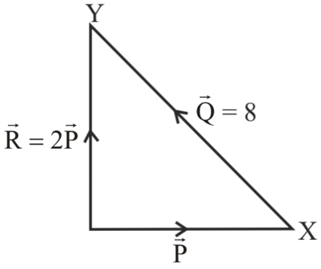
(c) $\frac{12}{\sqrt{5}}$ (d) $\frac{16}{\sqrt{5}}$

AP EAMCET(Medical)-2004

Ans. (b) : Given,

$\vec{Q}=8$ units

$\vec{R}=2\vec{P}$



$\vec{Q}^2=\vec{R}^2+\vec{P}^2$

$(8)^2=(2\vec{P})^2+\vec{P}^2$

$=4\vec{P}^2+\vec{P}^2$

$64=5\vec{P}^2$

$\vec{P}^2=\frac{64}{5}\Rightarrow \vec{P}=\frac{8}{\sqrt{5}}$

17. Angle (in rad) made by the vector $\sqrt{3}\,\hat{i}+\hat{j}$ with the X-axis:

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{4}$

(c) $\frac{\pi}{3}$ (d) $\frac{\pi}{2}$

AP EAMCET(Medical)-2005

Ans. (a): $\vec{A}=\sqrt{3}\,\hat{i}+\hat{j}$

Angle with x–axis :

$\cos\theta=\frac{A_x}{|\vec{A}|}$

$\cos\theta=\frac{\sqrt{3}}{\sqrt{\left(\sqrt{3}\right)^2+(1)^2}}=\frac{\sqrt{3}}{2}$

$\theta=30°$

$\theta=\frac{\pi}{6}$

18. The unit vector parallel to resultant of the vectors $\vec{A}=4\hat{i}+3\hat{j}+6\hat{k}$ and $\vec{B}=-\hat{i}+3\hat{j}-8\hat{k}$ is:

(a) $\frac{1}{7}\left(3\hat{i}+3\hat{j}-2\hat{k}\right)$ (b) $\frac{1}{7}\left(3\hat{i}+6\hat{j}-2\hat{k}\right)$

(c) $\frac{1}{49}\left(3\hat{i}+6\hat{j}-2\hat{k}\right)$ (d) $\frac{1}{49}\left(3\hat{i}-6\hat{j}+2\hat{k}\right)$

AP EAMCET(Medical)-2000

Ans. (b) : $\vec{A}=4\hat{i}+3\hat{j}+6\hat{k}$

$\vec{B}=-\hat{i}+3\hat{j}-8\hat{k}$

$\vec{R}=\vec{A}+\vec{B}=(4\hat{i}+3\hat{j}+6\hat{k})+(-\hat{i}+3\hat{j}-8\hat{k})$

$\vec{R}=3\hat{i}+6\hat{j}-2\hat{k}$

unit vector, $\hat{R}=\frac{\vec{R}}{|\vec{R}|}$

$|\vec{R}|=\sqrt{3^2+6^2+2^2}$

$=\sqrt{9+36+4}$

$=\sqrt{49}$

$|\vec{R}|=7$

$\hat{R}=\frac{3\hat{i}+6\hat{j}-2\hat{k}}{7}$

$\hat{R}=\frac{1}{7}\left(3\hat{i}+6\hat{j}-2\hat{k}\right)$

19. Pressure is a scalar quantity because

(a) it is the ratio of force to area and both force and area are vector quantities

(b) it is the ratio of magnitude of force to area

(c) it is the ratio of component of the force normal to the area

(d) it depends on the size of the area chosen

SCRA-2015

Ans. (c) : Pressure is a scalar quantity because pressure is the ratio of normal force to the area and the direction of force is not required.

20. The component of a vector r along X-axis will have a maximum value, if :

(a) r is along positive X-axis

(b) r is along positive Y-axis

(c) r is along negative Y-axis

(d) r makes an angle of 45^0 with the X-axis

Karnataka CET-2016

@apna_pdf

Ans. (a) : $r_x = r\cos\theta$

r_x is maximum when $\theta = 0$

r will be along positive X-axis for maximum value.

21. Which of the following is not a vector quantity?

(a) Weight (b) Nuclear spin

(c) Momentum (d) Potential energy

Karnataka CET-2014

Ans. (d) : Weight, Nuclear spin and Momentum are vector quantities because they have both magnitude as well as direction, whereas potential energy has magnitude only but no direction, thus it is a scalar quantity.

22. Two equal forces (P each) act at a point inclined to each other at an angle of 120^0. the magnitude of their resultant is :

(a) P/2 (b) P/4

(c) P (d) 2P

Karnataka CET-2004

Ans. (c) : Given, Q = P, θ = 120°

$$\because\ R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$= \sqrt{P^2 + P^2 + 2P \times P\cos 120°}$$

$$= \sqrt{P^2 + P^2 - \left(2P \times P \times \frac{1}{2}\right)} = P$$

23. The resultant of two forces 3P and 2P is R. If the first force is doubled then the resultant is also doubled. The angle between the two forces is :

(a) 90^0 (b) 180^0

(c) 60^0 (d) 120^0

Karnataka CET-2001

Ans. (d) : Case – I

$$R = \sqrt{(3P)^2 + (2P)^2 + 12P^2\cos\theta}$$

$$R = P\sqrt{13 + 12\cos\theta}$$

Case -II

$$R_1 = \sqrt{(6P)^2 + (2P)^2 + 24P^2\cos\theta}$$

$$= P\sqrt{40 + 24\cos\theta}$$

From case (I) and case (II),

$$\frac{R_1}{R} = \sqrt{\frac{40 + 24\cos\theta}{13 + 12\cos\theta}} = 2 \qquad [\because R_1 = 2R]$$

$$40 + 24\cos\theta = 52 + 48\cos\theta$$

$$24\cos\theta = -12$$

$$\cos\theta = -\frac{1}{2} \Rightarrow \theta = \cos^{-1}\left(-\frac{1}{2}\right)$$

$$\theta = 120^0$$

24. Three vectors satisfy the relation $\vec{A}.\vec{B} = 0$ and $\vec{A}.\vec{C} = 0$ then $\vec{A}$ is parallel to :

(a) $\vec{C}$ (b) $\vec{B}$

(c) $\vec{B} \times \vec{C}$ (d) $\vec{B}.\vec{C}$

JCECE-2013
COMEDK 2013
Karnataka CET-2003

Ans. (c) : $\vec{A}.\vec{B} = 0 \Rightarrow \vec{A} \perp \vec{B}$

$\vec{A}.\vec{C} = 0 \Rightarrow \vec{A} \perp \vec{C}$

$\vec{A}$ is perpendicular to both $\vec{B}$ and $\vec{C}$ and $\vec{B} \times \vec{C}$ is also perpendicular to both $\vec{B}$ and $\vec{C}$.

Therefore, $\vec{A}$ is parallel to $\vec{B} \times \vec{C}$

25. Three forces F_1, F_2 and F_3 together keep a body in equilibrium. If F_1 = 3 N along the positive x-axis, F_2 = 4 N along the positive y-axis, then the third force F_3 is

(a) 5N making an angle $\theta = \tan^{-1}\left(\frac{3}{4}\right)$ with negative y-axis

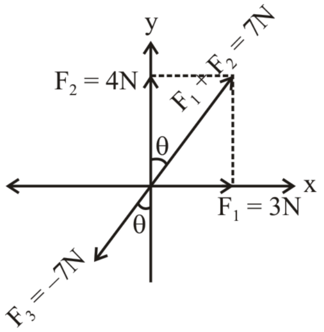
(b) 5N making an angle $\theta = \tan^{-1}\left(\frac{4}{3}\right)$ with negative y-axis

(c) 7N making an angle $\theta = \tan^{-1}\left(\frac{3}{4}\right)$ with negative y-axis

(d) 7N making an angle $\theta = \tan^{-1}\left(\frac{4}{3}\right)$ with negative y-axis

J&K CET- 2010

Ans. (c) : F_1, F_2, F_3 keep a body in equilibrium then resultant of force,



ΣF = 0

$F_1 + F_2 + F_3 = 0$

$3 + 4 + F_3 = 0$

$F_3 = -7N$

Magnitude of F_3 = 7N

θ is angle made with-Y axis

$$\tan\theta = \frac{3}{4}$$

$\theta = \tan^{-1} 3/4$

F_3 make angle with negative y-axis.

26. Magnitudes of four pairs of displacement vectors are given. Which pair of displacement vectors, under vector addition, fails to give a resultant vector of magnitude 3 cm ?

(a) 2 cm, 7 cm (b) 1 cm, 4 cm

(c) 2 cm, 3 cm (d) 2 cm, 4 cm

J&K CET- 2009

@apna_pdf

Ans. (a) : The magnitude R of the resultant of two vectors A and B depends upon the magnitudes of A and B and the angle θ between them and is given by

$$R^2 = A^2 + B^2 + 2AB\cos\theta$$

When θ = 0, R is maximum and given by

$$R_{max}^2 = A^2 + B^2 + 2AB = (A+B)^2$$

$$R_{max} = A + B$$

When θ = 180°, R is minimum and given by

$$R_{min}^2 = A^2 + B^2 - 2AB = (A-B)^2$$

$$R_{min} = A - B$$

Thus, the magnitude of resultant will lie between A – B and A + B.

Now,

Checking option (a)

$|A - B| = |2 - 7| = 5$

$|A + B| = |2 + 7| = 9$

So, $5 \le R \le 9$ and R = 4

Hence, the option (a) is the correct answer.

27. A body is under the action of two mutually perpendicular forces of 3N and 4N. The resultant force acting on the body is

(a) 7 N (b) 1 N

(c) 5 N (d) zero

J&K CET- 2008

Ans. (c) : The two forces be

A = 3N and B = 4N

A is mutually perpendicular to B.

$\therefore$ θ = 90°

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$R = \sqrt{4^2 + (3)^2 + 2AB\cos 90°}$$

$$R = \sqrt{16 + 9 + 0}$$

$$R = 5N$$

28. If the scalar and vector products of two vectors $\vec{A}, \vec{B}$ are equal in magnitude, then the angle between the two vectors is

(a) 45° (b) 90°

(c) 180° (d) 360°

J&K CET- 2008

Ans. (a) : A.B = A × B

$|A||B|\cos\theta = |A||B|\sin\theta$

$$\frac{\sin\theta}{\cos\theta} = \frac{|A||B|}{|A||B|}$$

$\tan\theta = 1$

$\theta = 45°$

29. $\vec{A}$ is a vector with magnitude A, then the unit vector $\hat{A}$ in the direction of $\vec{A}$ is

(a) $A\vec{A}$ (b) $\vec{A}\cdot\vec{A}$

(c) $\vec{A}\times\vec{A}$ (d) $\frac{\vec{A}}{A}$

J&K CET- 2008

Ans. (d) : Unit vector $\hat{A} = \frac{\vec{A}}{|\vec{A}|} = \frac{\vec{A}}{A}$

30. Two vectors are given by $\vec{A} = 3\hat{i} + \hat{j} + 3\hat{k}$ and $\vec{B} = 3\hat{i} + 5\hat{j} - 2\hat{k}$. Find the third vector $\vec{C}$ if $\vec{A} + 3\vec{B} - \vec{C} = 0$

(a) $12\hat{i} + 14\hat{j} + 12\hat{k}$ (b) $13\hat{i} + 17\hat{j} + 12\hat{k}$

(c) $12\hat{i} + 16\hat{j} - 3\hat{k}$ (d) $15\hat{i} + 13\hat{j} + 4\hat{k}$

J&K CET- 2007

Ans. (c) : Given, $\vec{A} = 3\hat{i} + \hat{j} + 3\hat{k}$, $\vec{B} = 3\hat{i} + 5\hat{j} - 2\hat{k}$

$$\vec{A} + 3\vec{B} - \vec{C} = 0$$

$$3\hat{i} + \hat{j} + 3\hat{k} + 3\left(3\hat{i} + 5\hat{j} - 2\hat{k}\right) - \vec{C} = 0$$

$$3\hat{i} + \hat{j} + 3\hat{k} + 9\hat{i} + 15\hat{j} - 6\hat{k} - \vec{C} = 0$$

$$12\hat{i} + 16\hat{j} - 3\hat{k} - \vec{C} = 0$$

$$\vec{C} = 12\hat{i} + 16\hat{j} - 3\hat{k}$$

31. Vector which is perpendicular to a $(a\cos\theta\,\hat{i} + b\sin\theta\,\hat{j})$ is

(a) $b\sin\theta\hat{i} - a\cos\theta\hat{j}$ (b) $\frac{1}{a}\sin\theta\hat{i} - \frac{1}{b}\cos\theta\hat{j}$

(c) $5\hat{k}$ (d) all of these

J&K CET- 2006

Ans. (d) : Two vectors are perpendicular if their dot product is zero i.e., $\vec{A}\cdot\vec{B} = 0$.

In option (a)

$$\left(a\cos\theta\hat{i} + b\sin\theta\hat{j}\right)\cdot\left(b\sin\theta\hat{i} - a\cos\theta\hat{j}\right)$$

$$= ab\cos\theta\sin\theta - ab\sin\theta\cos\theta = 0$$

In option (b)

$$(a\cos\theta\hat{i} + b\sin\theta\hat{j})\cdot(\frac{1}{a}\sin\theta\hat{i} - \frac{1}{b}\cos\theta\hat{j})$$

$$= \sin\theta\cos\theta - \sin\theta\cos\theta = 0$$

In option (c)

$$(a\cos\theta\hat{i} + b\sin\theta\hat{j})\cdot\left(5\hat{k}\right) = 0.$$

32. Velocity is

(a) scalar

(b) vector

(c) neither scalar nor vector

(d) both scalar and vector

J&K CET- 2002

Ans. (b) : A vector quantity is defined as the physical quantity that has both magnitude as well as direction.

Velocity is the directional speed of a object in motion and indication of rate of change in position as observed by a particular frame of reference.

Velocity is a physical vector quantity.

33. The sum of two vectors $\vec{A}$ and $\vec{B}$ is at right angles to their difference. Then

(a) A = B

(b) A = 2B

(c) B = 2A

(d) $\vec{A}$ and $\vec{B}$ have the same direction

BCECE-2008
J & K CET - 1998
UP CPMT - 2006

@apna_pdf

Ans. (a) : Let r_1 and r_2 be the sum and difference of vectors $\vec{A}$ and $\vec{B}$ respectively i.e.,

$$r_1 = \vec{A} + \vec{B}$$
$$r_2 = \vec{A} - \vec{B}$$

r_1 is perpendicular to r_2 (given)

Taking the dot product of r_1 and r_2

$$r_1 . r_2 = (\vec{A} + \vec{B}) . (\vec{A} - \vec{B})$$
$$0 = A^2 - B^2$$
$$A^2 = B^2$$
$$A = B$$

34. The vectors $\vec{A}$ and $\vec{B}$ are such that

$$\left|\vec{A}+\vec{B}\right| = \left|\vec{A}-\vec{B}\right|$$

The angle between the two vectors is

(a) 60° (b) 75°
(c) 45° (d) 90°

WBJEE-2016,
AIIMS-25.05.2019(E) Shift-2
J&K CET- 2003, 1999

Ans. (d) : Let angle between $\vec{A}$ and $\vec{B}$ be θ

The resultant of $\vec{A}+\vec{B}$ is given by

$$R = \sqrt{A^2+B^2+2AB\cos\theta}$$

The resultant of $\vec{A}-\vec{B}$ is given by

$$R' = \sqrt{A^2+B^2-2AB\cos\theta}$$

According to the question,

$$R = R'$$
$$\sqrt{A^2+B^2+2AB\cos\theta} = \sqrt{A^2+B^2-2AB\cos\theta}$$
$$A^2+B^2+2AB\cos\theta = A^2+B^2-2AB\cos\theta$$
$$4AB\cos\theta = 0$$
$$\theta = 90^\circ$$

35. The vector sum of two forces is perpendicular to their vector differences. In that case, the forces

(a) are not equal to each other in magnitude
(b) cannot be predicted
(c) are equal to each other
(d) are equal to each other in magnitude

[AIPMT 2003]
AIIMS- 2012
TS-EAMCET - 09.09.2020

Ans. (d) : Let $\vec{f_1}$ and $\vec{f_2}$ be the two forces

Then sum of forces, $\vec{a} = \vec{f_1} + \vec{f_2}$

And difference, $\vec{b} = \vec{f_1} - \vec{f_2}$

The two forces are perpendicular to each other $\left(\vec{a}.\vec{b}\right) = 0$

$$\left(\vec{f_1}+\vec{f_2}\right).\left(\vec{f_1}-\vec{f_2}\right) = 0$$
$$|\vec{f_1}|^2 - |\vec{f_2}|^2 = 0$$
$$|\vec{f_1}|^2 = |\vec{f_2}|^2$$
$$|\vec{f_1}| = |\vec{f_2}|$$

In that case both the force are equal and have same magnitude.

36. The sum of two vectors $\vec{A}$ and $\vec{B}$ is at right angles to their difference. This is possible if

(a) A = 2B (b) A = B
(c) A = 3B (d) B = 2A

J&K CET- 1998

Ans. (b) : Let, $\vec{P_1}$ and $\vec{P_2}$ sum and difference of vectors $\vec{A}$ and $\vec{B}$,

$$\vec{P_1} = (\vec{A} + \vec{B})$$
$$\vec{P_2} = (\vec{A} - \vec{B})$$
$$\vec{P_1} . \vec{P_2} = (\vec{A} + \vec{B}).(\vec{A} - \vec{B})$$
$$0 = A^2 - B^2$$
$$A^2 = B^2$$
$$A = B$$

37. What is the torque of a force $3\hat{i}+7\hat{j}+4\hat{k}$ about the origin, if the force acts on a particle whose position vector is $2\hat{i}+2\hat{j}+1\hat{k}$?

(a) $\hat{i}-5\hat{j}+8\hat{k}$ (b) $2\hat{i}+2\hat{j}+2\hat{k}$
(c) $\hat{i}+\hat{j}+\hat{k}$ (d) $3\hat{i}+2\hat{j}+3\hat{k}$

J&K-CET-2014

Ans. (a) : Given that,

$$\vec{F} = 3\hat{i}+7\hat{j}+4\hat{k}$$
$$\vec{r} = 2\hat{i}+2\hat{j}+1\hat{k}$$
$$\tau = \vec{r}\times\vec{F}$$
$$\tau = \begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 2 & 2 & 1\\ 3 & 7 & 4\end{vmatrix}$$
$$\tau = \hat{i}\ (8-7) - \hat{j}\ (8-3) + \hat{k}\ (14-6)$$
$$\tau = \hat{i}-5\hat{j} + 8\hat{k}$$

38. The scalar product of two vectors $\vec{A} = 2\hat{i}+2\hat{j}-\hat{k}$ and $\vec{B} = -\hat{j}+\hat{k}$ is given by

(a) $\vec{A}.\vec{B} = 3$ (b) $\vec{A}.\vec{B} = 4$
(c) $\vec{A}.\vec{B} = -4$ (d) $\vec{A}.\vec{B} = -3$

J&K-CET-2013

Ans. (d) : Given that,

$$\vec{A} = 2\hat{i}+2\hat{j}-\hat{k}, \quad \vec{B} = -\hat{j}+\hat{k} = 0\hat{i}-\hat{j}+\hat{k}$$
$$\vec{A}.\vec{B} = \left(2\hat{i}+2\hat{j}-\hat{k}\right).\left(0\hat{i}-\hat{j}+\hat{k}\right)$$
$$= 0 + 2\times(-1) + (-1)\times 1$$
$$= -2 - 1 = -3$$

39. The velocity vector of the motion described by the position vector of a particle r = $2t\hat{i}+t^2\hat{j}$ is

(a) $v = 2\hat{i}+2t\hat{j}$ (b) $v = 2t\hat{i}+2t\hat{j}$
(c) $v = t\hat{i}+t^2\hat{j}$ (d) $v = 2\hat{i}+t^2\hat{j}$

J&K-CET-2013

@apna_pdf

Ans. (a) : Given, $r = 2t\hat{i} + t^2\hat{j}$

Velocity $(\vec{v}) = \frac{dr}{dt}$

$\frac{dr}{dt} = 2\hat{i} + 2t\hat{j}$

40. A certain vector in the xy plane has an x-component of 12 m and a y-component of 8 m. It is then rotated in the xy plane so that its x-component is halved. Then its new y-component is approximately

(a) 14 m (b) 13.11 m
(c) 10 m (d) 2.0 m

J&K-CET-2012

Ans. (b) : x – component = 12cm
y – component = 8cm
Length of the resultant vector (R)

$= \sqrt{x^2 + y^2} = \sqrt{12^2 + 8^2}$

$= \sqrt{144 + 64} = \sqrt{208}$

Now,

$x' = \frac{x}{2} = \frac{12}{2} = 6\,cm$

Resultant will always be constant even after the rotation
So,

$\sqrt{(x')^2 + (y')^2} = \sqrt{208}$

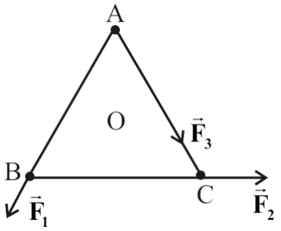
$(6)^2 + (y')^2 = 208$

$(y')^2 = 208 - 36 = 172$

$(y') = \sqrt{172}$

$(y') = 13.11m$

41. Figure shows three forces $\vec{F}_1, \vec{F}_2$ and $\vec{F}_3$ acting along the sides of an equilateral triangle. If the total torque acting at point 'O' (centre of the triangle) is zero then the magnitude of $\vec{F}_3$ is



(a) F_1+F_2 (b) F_1-F_2
(c) $\frac{F_1 - F_2}{2}$ (d) $\frac{F_1}{F_2}$

MHT-CET 2020

Ans. (a) : Force $\vec{F}_1$ and $\vec{F}_2$ produce anticlockwise torque while force $\vec{F}_3$ produces clockwise torque. The torque in the two directions balance each other. The perpendicular distance of the forces from the centre is the same.

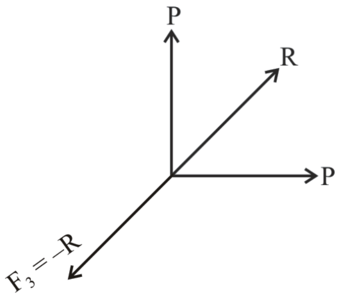
$\therefore F_1r + F_2r = F_3r$ or $F_1+F_2 = F_3$

42. Two forces each of magnitude 'P' act at right angles. Their effect is neutralized by a third force acting along their bisector in opposite direction. The magnitude of the third force is $\left[\cos\frac{\pi}{2} = 0\right]$

(a) P (b) $\frac{P}{\sqrt{2}}$
(c) $\sqrt{2}P$ (d) $\frac{P}{2}$

MHT-CET 2020

Ans. (c) : The third force will have magnitude equal to their resultant,



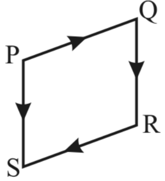
$R = \sqrt{R_1^2 + R_2^2 + 2R_1R_2\cos\theta}$

$R = \sqrt{P^2 + P^2 + 2.P.P\cos 90°}$

$R = \sqrt{2P^2}$

$R = \sqrt{2}P$

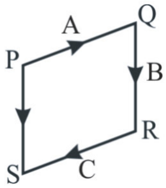
43. In the given diagram, if PQ = A, QR = B and RS = C, then PS equals



(a) A – B + C (b) A + B – C
(c) A + B + C (d) A – B – C
(e) – A – B – C

Kerala CEE - 2016

Ans. (c) : Given, PQ = A, QR = B, RS = C, PS = ?



According to polygon law of vector addition,
PQ + QR + RS – PS = 0
PS = PQ + QR + RS
PS = A + B + C

44. Among the following, the vector quantity is

(a) pressure (b) gravitation potential
(c) stress (d) impulse
(e) distance

Kerala CEE 2012

@apna_pdf

Ans. (d) : Impulse is defined as the product of net force and time interval for which it was applied.

i.e. Impulse = $\vec{F}t$

Force is vector quantity. Therefore, Impulse is a vector quantity. Stress is a tensor quantity.

45. The sum of magnitudes of two forces acting at a point is 16 N and their resultant $8\sqrt{3}$ N is at 90° with the force of smaller magnitude. The two forces (in N) are

(a) 11, 5
(b) 9, 7
(c) 6, 10
(d) 4, 12
(e) 2, 14

Kerala CEE 2012

Ans. (e) : Given,

$$P + Q = 16$$
$$R = 8\sqrt{3}$$
$$\because R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$
$$8\sqrt{3} = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$
$$\because \tan 90^\circ = \frac{\sin\theta}{P + Q\cos\theta} = \infty$$
$$P + Q\cos\theta = 0 \Rightarrow \cos\theta = -\frac{P}{Q}$$

So,

$$8\sqrt{3} = \sqrt{P^2 + Q^2 + 2PQ\left(-\frac{P}{Q}\right)}$$
$$8\sqrt{3} = \sqrt{P^2 + Q^2 - 2P^2} \Rightarrow 8\sqrt{3} = \sqrt{Q^2 - P^2}$$
$$Q^2 - P^2 = 192$$
$$\therefore Q^2 - (16 - Q)^2 = 192 \qquad (\because P = 16 - Q)$$
$$Q^2 - 256 - Q^2 + 32Q = 192$$
$$32Q = 448$$
$$Q = 14\text{ N}$$

Now, from P + Q = 16

$$P = 16 - 14 = 2\text{N}$$
$$P = 2\text{N}$$
$$Q = 14\text{N}$$

46. A force $(4\hat{i} + \hat{j} - 2\hat{k})$ N acting on a body maintains its velocity at $(2\hat{i} + 2\hat{j} + 3\hat{k})$ ms^{-1}. The power exerted is

(a) 4 W
(b) 5 W
(c) 2 W
(d) 8 W
(e) 1 W

Kerala CEE - 2010

Ans. (a) : Given,

$$\vec{F} = (4\hat{i} + \hat{j} - 2\hat{k})$$
$$\vec{v} = (2\hat{i} + 2\hat{j} + 3\hat{k})$$

We know that,

$$P = \vec{F}\cdot\vec{v}$$
$$P = (4\hat{i} + \hat{j} - 2\hat{k})\cdot(2\hat{i} + 2\hat{j} + 3\hat{k})$$
$$(\text{where, } \hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1)$$
$$P = 8 + 2 - 6 \Rightarrow P = 4\text{W}$$

47. A particle acted upon by constant forces $4\hat{i} + \hat{j} - 3\hat{k}$ and $3\hat{i} + \hat{j} - \hat{k}$ is displaced from the point $\hat{i} + 2\hat{j} + 3\hat{k}$ to the point $5\hat{i} + 4\hat{j} + \hat{k}$. The total work done by the forces in SI unit is

(a) 20
(b) 40
(c) 50
(d) 30
(e) 35

Kerala CEE - 2008

Ans. (b) : Given,

$$\vec{F}_1 = 4\hat{i} + \hat{j} - 3\hat{k}$$
$$\vec{F}_2 = 3\hat{i} + \hat{j} - \hat{k}$$
$$\vec{r}_1 = \hat{i} + 2\hat{j} + 3\hat{k}$$
$$\vec{r}_2 = 5\hat{i} + 4\hat{j} + \hat{k}$$

Now force, $\vec{F}_R = \vec{F}_1 + \vec{F}_2$

$$\vec{F}_R = (4\hat{i} + \hat{j} - 3\hat{k}) + (3\hat{i} + \hat{j} - \hat{k})$$
$$\vec{F}_R = 7\hat{i} + 2\hat{j} - 4\hat{k}$$

Displacement, $\vec{dr} = \vec{r}_2 - \vec{r}_1$

$$\vec{dr} = (5\hat{i} + 4\hat{j} + \hat{k}) - (\hat{i} + 2\hat{j} + 3\hat{k})$$
$$\vec{dr} = 4\hat{i} + 2\hat{j} - 2\hat{k}$$

Work done by the forces, $W = \vec{F}_R.\vec{dr}$

$$= (7\hat{i} + 2\hat{j} - 4\hat{k}).(4\hat{i} + 2\hat{j} - 2\hat{k})$$
$$(\text{where, } \hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1)$$
$$W = 28 + 4 + 8$$
$$W = 40\text{J}$$

48. If the two vectors $\vec{A} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ and $\vec{B} = \hat{i} + 2\hat{j} - n\hat{k}$ are perpendicular then the value of n is :

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

Kerala CEE 2006

Ans. (b) : Given,

$$\vec{A} = 2\hat{i} + 3\hat{j} + 4\hat{k}$$
$$\vec{B} = \hat{i} + 2\hat{j} - n\hat{k}$$

If two vectors are perpendicular then their scalar product is zero.

$$\therefore \vec{A}.\vec{B} = 0$$
$$(2\hat{i} + 3\hat{j} + 4\hat{k})\cdot(\hat{i} + 2\hat{j} - n\hat{k}) = 0$$
$$2 + 6 - 4n = 0$$
$$n = 2$$

49. A particle is displaced from a position $(2\hat{i} - \hat{j} + \hat{k})$ to another position $(3\hat{i} + 2\hat{j} - 2\hat{k})$ under the action of the force of $(2\hat{i} + \hat{j} - \hat{k})$. The work done by the force in an arbitrary unit is:

(a) 8
(b) 10
(c) 12
(d) 16
(e) 20

JCECE-2018
Kerala CEE 2005

@apna_pdf

Ans. (a) : Given that,

$\vec{F} = 2\hat{i} + \hat{j} - \hat{k}$

$\vec{r}_1 = 2\hat{i} - \hat{j} + \hat{k}$

$\vec{r}_2 = 3\hat{i} + 2\hat{j} - 2\hat{k}$

$W = \vec{F}.\vec{dr}$

$W = (2\hat{i} + \hat{j} - \hat{k}).(\vec{r}_2 - \vec{r}_1) \qquad (\because \vec{dr} = \vec{r}_2 - \vec{r}_1)$

$= (2\hat{i} + \hat{j} - \hat{k}) \cdot \left[(3\hat{i} + 2\hat{j} - 2\hat{k}) - (2\hat{i} - \hat{j} + \hat{k})\right]$

$= (2\hat{i} + \hat{j} - \hat{k}).(\hat{i} + 3\hat{j} - 3\hat{k}) = 2 + 3 + 3$

$\therefore$ W = 8 unit

50. If a vector A is given as $A = 4\hat{i} + 3\hat{j} + 12\hat{k}$, then the angle subtended with the x-axis is

(a) $\sin^{-1}\left[\frac{4}{13}\right]$ (b) $\sin^{-1}\left[\frac{3}{13}\right]$

(c) $\cos^{-1}\left[\frac{3}{13}\right]$ (d) $\cos^{-1}\left[\frac{4}{13}\right]$

COMEDK-2019
UPSEE - 2015

Ans. (d) : Given, $A = 4\hat{i} + 3\hat{j} + 12\hat{k}$

Let θ be the angle made by vector A with X-axis.

$\therefore \cos\theta = \frac{A_x}{|A|}$

$\cos\theta = \frac{4}{\sqrt{4^2 + 3^2 + 12^2}} = \frac{4}{13}$

$$\boxed{\theta = \cos^{-1}\left(\frac{4}{13}\right)}$$

51. The angle between two vectors A and B is θ. Vector R is the resultant of the two vectors. If R makes an $\frac{\theta}{2}$ with A, then

(a) A = 2B (b) $A = \frac{B}{2}$

(c) A = B (d) AB = 1

UPSEE - 2013

Ans. (c) : The angle α which the resultant $\vec{R}$ makes with $\vec{A}$ is given by–

$\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta} \qquad$ Here, $\alpha = \frac{\theta}{2}$

Hence, $\tan\frac{\theta}{2} = \frac{B\sin\theta}{A + B\cos\theta}$

$\frac{\sin\frac{\theta}{2}}{\cos\frac{\theta}{2}} = \frac{2B\sin(\theta/2)\cos(\theta/2)}{A + B\cos\theta}$

$A + B\cos\theta = 2B\cos^2(\theta/2)$

$A + B[2\cos^2(\theta/2) - 1] = 2B\cos^2(\theta/2)$

$A + 2B\cos^2\left(\frac{\theta}{2}\right) - B = 2B\cos^2\left(\frac{\theta}{2}\right)$

A – B = 0

$\therefore$ A = B

52. The power utilised when a force of $(2\hat{i} + 3\hat{j} + 4\hat{k})$N acts on a body for 4s, producing a displacement of $(3\hat{i} + 4\hat{j} + 5\hat{k})$ m, is

(a) 9.5 W (b) 7.5 W

(c) 6.5 W (d) 4.5 W

AP EAMCET (21.09.2020) Shift-I

Ans. (a) : Power $= \vec{F}.\vec{v}$

And, $\vec{v} = \frac{\vec{d}}{t}$

$\vec{v} = \frac{3\hat{i} + 4\hat{j} + 5\hat{k}}{4}$

$\therefore$ Power $= (2\hat{i} + 3\hat{j} + 4\hat{k}).\frac{(3\hat{i} + 4\hat{j} + 5\hat{k})}{4}$

$= 2 \times \frac{3}{4} + 3 \times \frac{4}{4} + 4 \times \frac{5}{4}$

$= \frac{6}{4} + \frac{12}{4} + \frac{20}{4} = \frac{6 + 12 + 20}{4}$

$= \frac{38}{4}$

Power = 9.5 W

53. $\vec{A} = 4\hat{i} + 3\hat{j}$ and $\vec{B} = 4\hat{i} + 2\hat{j}$. Find a vector parallel to $\vec{A}$ but has magnitude five times that of $\vec{B}$.

(a) $\sqrt{20}(2\hat{i} + 3\hat{j})$ (b) $\sqrt{20}(4\hat{i} + 3\hat{j})$

(c) $\sqrt{20}(2\hat{i} + \hat{j})$ (d) $\sqrt{10}(2\hat{i} + \hat{j})$

BITSAT-2007

Ans. (b) : Given, $\vec{A} = 4\hat{i} + 3\hat{j}$, $\vec{B} = 4\hat{i} + 2\hat{j}$

$\hat{A} = \frac{\vec{A}}{|\vec{A}|} = \frac{4\hat{i} + 3\hat{j}}{\sqrt{4^2 + 3^2}}$

$\hat{A} = \frac{1}{5}(4\hat{i} + 3\hat{j})$

$\vec{P} = 5|\vec{B}|\hat{A}$

$= 5 \times \sqrt{4^2 + 2^2} \times \frac{1}{5}(4\hat{i} + 3\hat{j})$

$\vec{P} = \sqrt{20}(4\hat{i} + 3\hat{j})$

54. Given that $\vec{A} + \vec{B} = \vec{R}$ and $A^2 + B^2 = R^2$ The angle between $\vec{A}$ and $\vec{B}$ is

(a) 0 (b) π/4

(c) π/2 (d) π

BITSAT-2009

Ans. (c) : Given, $\vec{A} + \vec{B} = \vec{R}$ and $A^2 + B^2 = R^2$

$R^2 = A^2 + B^2 + 2AB\cos\theta$

Where, θ = Angle between A & B,

$\because R^2 = A^2 + B^2$

$\therefore A^2 + B^2 = A^2 + B^2 + 2AB\cos\theta$

$\therefore \cos\theta = 0$

$\theta = \frac{\pi}{2}$

@apna_pdf

55. **The two vectors $\vec{A}$ and $\vec{B}$ are drawn from a common point and $\vec{C} = \vec{A} + \vec{B}$, then angle between $\vec{A}$ and $\vec{B}$ is**
(1) 90° if $C^2 = A^2 + B^2$
(2) greater than 90° if $C^2 < A^2 + B^2$
(3) greater than 90° if $C^2 > A^2 + B^2$
(4) less than 90° if $C^2 > A^2 + B^2$
Correct options are-
(a) 1,2
(b) 1, 2, 3, 4
(c) 2, 3, 4
(d) 1, 2, 4

BITSAT-2011

Ans. (d) : $\vec{C} = \vec{A} + \vec{B}$

$\because \quad C^2 = A^2 + B^2 + 2AB\cos\theta$

$$\cos\theta = \frac{C^2 - (A^2 + B^2)}{2AB}$$

Case-I, $C^2 = A^2 + B^2$

$$\cos\theta = \frac{A^2 + B^2 - (A^2 + B^2)}{2AB} = 0$$

$\theta = \pi/2$ or 90°

Case-II, $C^2 < A^2 + B^2$

$$\cos\theta = \frac{C^2 - (A^2 + B^2)}{2AB} (-\text{ve})$$

Then, $\theta > 90°$

Case-III, $C^2 > A^2 + B^2$

$$\cos\theta = \frac{C^2 - (A^2 + B^2)}{2AB} (+\text{ve})$$

Then, $\theta < 90°$

56. **Given $\vec{P} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ and $\vec{Q} = \hat{j} - 2\hat{k}$. The magnitude of their resultant is**
(a) $\sqrt{3}$
(b) $2\sqrt{3}$
(c) $3\sqrt{3}$
(d) $4\sqrt{3}$

BITSAT -2018

Ans. (b) : Given, P = $2\hat{i} - 3\hat{j} + 4\hat{k}$, $\vec{Q} = \hat{j} - 2\hat{k}$

$$\vec{R} = \vec{P} + \vec{Q}$$
$$= (2\hat{i} - 3\hat{j} + 4\hat{k}) + (\hat{j} - 2\hat{k})$$

$\vec{R} = 2\hat{i} - 2\hat{j} + 2\hat{k}$

$|\vec{R}| = \sqrt{(2)^2 + (-2)^2 + (2)^2}$

$|\vec{R}| = 2\sqrt{3}$

57. **The position vector of a point is $\vec{R} = x\hat{i} + y\hat{j} + z\hat{k}$ and another vector is $\vec{A} = 3\hat{i} + 2\hat{j} + 5\hat{k}$. Which of the mathematical relation is correct?**
(a) $\nabla\left(\hat{A}\,\hat{R}\right) = 0$
(b) $\nabla\left(\vec{A}\,\vec{R}\right) = \vec{A}$
(c) $\nabla\left(\vec{A}\,\vec{R}\right) = \vec{R}$
(d) None of these

CG PET- 2009

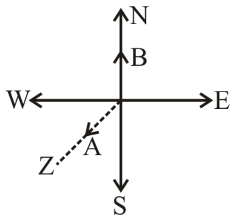
Ans. (b) : $\vec{R} = x\hat{i} + y\hat{j} + z\hat{k}$

$$\vec{A} = 3\hat{i} + 2\hat{j} + 5\hat{k}$$
$$\vec{A}\cdot\vec{R} = (x\hat{i} + y\hat{j} + z\hat{k})\cdot(3\hat{i} + 2\hat{j} + 5\hat{k})$$
$$\vec{A}\cdot\vec{R} = 3x + 2y + 5z$$
$$\nabla(\vec{A}\cdot\vec{R}) = \frac{d(3x)}{dx}\hat{i} + \frac{d(2y)}{dy}\hat{j} + \frac{d(5z)}{dz}\hat{k}$$
$$\nabla(\vec{A}\cdot\vec{R}) = 3\hat{i} + 2\hat{j} + 5\hat{k}$$
$$\nabla(\vec{A}\cdot\vec{R}) = \vec{A}$$

58. **The direction of $\vec{A}$ is vertically upward and direction of $\vec{B}$ is in north direction. The direction of $\vec{A}\times\vec{B}$ will be**
(a) Western direction
(b) Eastern direction
(c) At 45° upward in north
(d) Vertically downward

CG PET- 2009

Ans. (a) :



Considering vertically upward direction as z-axis and north direction as y-axis.

$\vec{A} = a\hat{k}$, $\vec{B} = b\hat{j}$

$\therefore\ \vec{A}\times\vec{B} = a\hat{k}\times b\hat{j} = ab(-\hat{i})$

Thus, it is along negative x-axis

$\therefore \vec{A}\times\vec{B}$ is along west.

59. **If $\vec{A} = \vec{B} + \vec{C}$ and the values of $\vec{A}, \vec{B}$ and $\vec{C}$ are 13, 12 and 5 respectively, then the angle between $\vec{A}$ and $\vec{C}$ will be**
(a) $\cos^{-1}(5/13)$
(b) $\cos^{-1}(13/12)$
(c) $\pi/2$
(d) $\sin^{-1}(5/12)$

CG PET- 2009

Ans. (a) : Given that, $\vec{A} = 13, \vec{B} = 12, \vec{C} = 5$

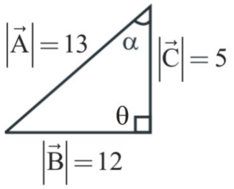
$A^2 = B^2 + C^2 + 2BC\cos\theta$

$(13)^2 = (12)^2 + (5)^2 + 2 \times 12 \times 5\cos\theta$

$\cos\theta = 0$

$\theta = 90°$

Hence, it is a right-angle triangle.



So, angle between $\vec{A}$ and $\vec{C}$ is,

$$\cos\alpha = \frac{5}{13} \Rightarrow \alpha = \cos^{-1}\left(\frac{5}{13}\right)$$

@apna_pdf

60. If $r_1 = 2\hat{x}, r_2 = 2\hat{y}$, where $\hat{x}$ and $\hat{y}$ are unit vectors along the X-axis and Y-axis respectively, then the magnitude of $r_1 + r_2$ is

(a) $2\sqrt{2}$ (b) $2\sqrt{3}$
(c) $3\sqrt{2}$ (d) $\sqrt{3}$

TS-EAMCET.14.09.2020, Shift-2

Ans. (a) : Given, $r_1 = 2\hat{x}, r_2 = 2\hat{y}$

$$r_1 + r_2 = 2\hat{x} + 2\hat{y}$$

Magnitude, $|r_1 + r_2| = \sqrt{2^2 + 2^2} = 2\sqrt{2}$

61. Let $A_1 + A_2 = 5A_3$, $A_1 - A_2 = 3A_3$, $A_3 = 2\hat{i} + 4\hat{j}$, then $\frac{|A_1|}{|A_2|}$ is

(a) 4 (b) 8
(c) 2 (d) 6

TS-EAMCET.14.09.2020, Shift-2

Ans. (a) : Given, $A_1 + A_2 = 5A_3$ ...(1)

$A_1 - A_2 = 3A_3$ ...(2)

Adding equation (1) & (2),

$2A_1 = 8A_3 \Rightarrow A_1 = 4A_3$

$\therefore A_1 = 8\hat{i} + 16\hat{j}$

Subtracting equation (2) from (1),

$2A_2 = 2A_3$

$\therefore A_2 = A_3 = 2\hat{i} + 4\hat{j}$

$$\frac{|A_1|}{|A_2|} = \frac{\sqrt{8^2 + 16^2}}{\sqrt{2^2 + 4^2}} = \sqrt{16} = 4$$

62. The magnitude of x and y components of A are 7 and 6 respectively. Also the magnitudes of x and y components of A+B are 11 and 9 respectively. Calculate the magnitude of vector B.

(a) 10 (b) 5
(c) 6 (d) 3

JCECE-2018

Ans. (b) : Given, $A = 7\hat{i} + 6\hat{j}$

$A + B = 11\hat{i} + 9\hat{j}$

Let, $B = b_1\hat{i} + b_2\hat{j}$

$(7\hat{i} + 6\hat{j}) + (b_1\hat{i} + b_2\hat{j}) = 11\hat{i} + 9\hat{j}$

$(7 + b_1)\hat{i} + (6 + b_2)\hat{j} = 11\hat{i} + 9\hat{j}$

$\therefore$ $7 + b_1 = 11 \Rightarrow b_1 = 4$

$6 + b_2 = 9 \Rightarrow b_2 = 3$

$\therefore$ $B = 4\hat{i} + 3\hat{j}$

$$|B| = \sqrt{4^2 + 3^2} = \sqrt{25} = 5$$

63. The position vector of a particle is $r = (\alpha\cos\omega t)\hat{i} + (\alpha\sin\omega t)\hat{j}$. The velocity vector of the particle is

(a) Parallel to position vector
(b) Perpendicular to position vector
(c) Directed towards the origin
(d) Directed away from the origin

JCECE-2014
BCECE - 2004

Ans. (b) : $\vec{r} = \alpha\cos\omega t\hat{i} + \alpha\sin\omega t\hat{j}$

$$\vec{v} = \frac{d\vec{r}}{dt} = (-\alpha\sin\omega t)\omega\hat{i} + (\alpha\cos\omega t)\omega\hat{j}$$

$\vec{v}.\vec{r} = \left[(-\alpha\omega\sin\omega t)\hat{i} + (\alpha\omega\cos\omega t)\hat{j}\right].\left[(\alpha\cos\omega t)\hat{i} + (\alpha\sin\omega t)\hat{j}\right]$

$= -\alpha^2\omega\sin\omega t.\cos\omega t + \alpha^2\omega\cos\omega t.\sin\omega t$

$\vec{v}.\vec{r} = 0$

$\because$ Dot product of $\vec{v}$ and $\vec{r}$ is zero

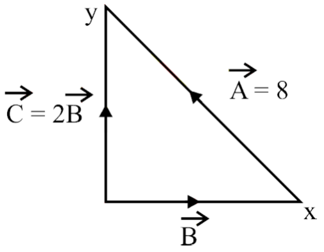
$\therefore$ Both are perpendicular to each other.

64. If a vector A having a magnitude of 8 is added to a vector B which lies along x-axis, then the resultant of two vectors lies along y-axis and has magnitude twice that of B. The magnitude of B is

(a) $\frac{6}{\sqrt{5}}$ (b) $\frac{12}{\sqrt{5}}$
(c) $\frac{16}{\sqrt{5}}$ (d) $\frac{8}{\sqrt{5}}$

JCECE-2012

Ans. (d) : Given,



$\vec{A} = 8$ units

Since, $\vec{B}$ is along x - axis and resultant of two vector $\vec{C}$ lies on y - axis

So, $\vec{B}$ and $\vec{C}$ are perpendicular vector.

Hence,

$$|\vec{A}|^2 = |\vec{B}|^2 + |\vec{C}|^2$$
$$|8|^2 = |B|^2 + |2B|^2$$
$$64 = 5B^2$$
$$B^2 = \frac{64}{5}$$
$$\therefore \quad B = \frac{8}{\sqrt{5}}$$

65. It two forces each of 2N are inclined at 60°, then resultant force is:

(a) 2 N (b) $2\sqrt{5}$N
(c) $2\sqrt{3}$N (d) $4\sqrt{2}$N

JCECE-2006

Ans. (c) : Let A & B be two forces,

$\therefore$ $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

$R = \sqrt{2^2 + 2^2 + 2\times2\times2\cos60^\circ}$ $(\cos 60^\circ = 1/2)$

$\therefore R = \sqrt{12} = 2\sqrt{3}$N

$\therefore R = 2\sqrt{3}$N

@apna_pdf

66. **Two vectors have magnitudes 3 and 5. If angle between them is 60º, then the dot product of two vectors will be :**

(a) 7.5 (b) 6.5
(c) 8.4 (d) 7.9

JCECE-2003

Ans. (a) : Let $\vec{A}$ & $\vec{B}$ be two vector,

$$\therefore \quad \vec{A}.\vec{B} = |A||B|\cos\theta$$
$$= 3 \times 5 \cos 60^{\circ}$$
$$= 15 \times \frac{1}{2}$$
$$\vec{A}\cdot\vec{B} = 7.5$$

67. **Calculate the work done when a force $\vec{F} = 2\hat{i} + 3\hat{j} - 5\hat{k}$ units acts on a body producing a displacement $\vec{s} = 2\hat{i} + 4\hat{j} + 3\hat{k}$ units :**

(a) 1 unit (b) 20 unit
(c) 5 unit (d) zero

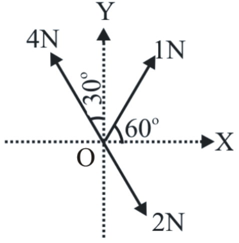
JCECE-2003

Ans. (a) : Given that, $\vec{F} = 2\hat{i} + 3\hat{j} - 5\hat{k}$

$$\vec{s} = 2\hat{i} + 4\hat{j} + 3\hat{k}$$
$$W = \vec{F}\cdot\vec{s}$$
$$W = (2\hat{i} + 3\hat{j} - 5\hat{k}).(2\hat{i} + 4\hat{j} + 3\hat{k})$$
$$W = 4 + 12 - 15$$

W = 1 Unit

68. **Three forces acting on a body are shown in the figure. To have the resultant force only along the y-direction, the magnitude of the minimum additional force needed along OX is**



(a) $\frac{\sqrt{3}}{4}$N (b) $\sqrt{13}$N
(c) 0.5 N (d) 1.5 N

COMEDK 2019

Ans. (c) : $\because \ R = \sqrt{\left(\sum F_x\right)^2 + \left(\sum F_y\right)^2}$

Let the additional force F be directed along the positive x-direction.

Taking x-component, the total force should be zero.

Let F be the magnitude of minimum force which must be along x-direction, by resolving the vector we get–

$1 \times \cos 60° + 2\sin 30° + F - 4\sin 30° = 0$

$$\frac{1}{2} + 1 + F - 2 = 0$$

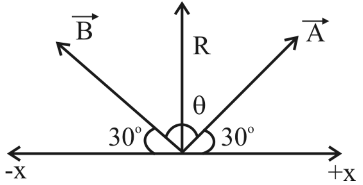
F = 1/2 = 0.5 N

69. **Vector A has a magnitude of 10 units and makes an angle of 30° with the positive x-axis. Vector B has a magnitude of 20 units and makes an angle of 30° with the negative x-axis. What is the magnitude of the resultant between these two vectors?**

(a) $20\sqrt{3}$ (b) 35
(c) $15\sqrt{3}$ (d) $10\sqrt{3}$

COMEDK 2015

Ans. (d) : The vector representation is as follows,



$$\therefore \ \theta = 180 - 30 - 30 = 120°$$
$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$
$$R = \sqrt{10^2 + 20^2 + 2 \times 10 \times 20 \times \cos 120^{\circ}}$$
$$R = \sqrt{100 + 400 - 200} \qquad \left(\because \cos 120° = -\frac{1}{2}\right)$$
$$R = \sqrt{300}$$
$$\therefore \qquad \boxed{R = 10\sqrt{3}\ \text{Unit}}$$

70. **Two vectors are given by $\vec{A} = (\hat{i} + 2\hat{j} + 2\hat{k})$ and $\vec{B} = (3\hat{i} + 6\hat{j} + 2\hat{k})$. Another vector $\vec{C}$ has the same magnitude as $\vec{B}$ but has the same direction as $\vec{A}$. Then which of the following vectors represents $\vec{C}$?**

(a) $\frac{7}{3}\left(\hat{i} + 2\hat{j} + 2\hat{k}\right)$ (b) $\frac{3}{7}\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$
(c) $\frac{7}{9}\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$ (d) $\frac{9}{7}\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$

COMEDK 2018

Ans. (a) : Given that, $\vec{A} = (\hat{i} + 2\hat{j} + 2\hat{k})$

$$\vec{B} = (3\hat{i} + 6\hat{j} + 2\hat{k})$$

Unit vector along direction of $\vec{A}$,

$$\hat{A} = \frac{\vec{A}}{|\vec{A}|} = \frac{\hat{i} + 2\hat{j} + 2\hat{k}}{\sqrt{1^2 + 2^2 + 2^2}} = \frac{1}{3}(\hat{i} + 2\hat{j} + 2\hat{k})$$

And, $|\vec{B}| = \sqrt{3^2 + 6^2 + 2^2}$

$$|\vec{B}| = \sqrt{49} = 7$$

Thus, vector $\vec{C}$ is–

$$\vec{C} = |\vec{B}|\hat{A}$$
$$\boxed{\vec{C} = \frac{7}{3}(\hat{i} + 2\hat{j} + 2\hat{k})}$$

71. **A particle starts moving from point (2,10,1). Displacement for the particle is $8\hat{i} - 2\hat{j} + \hat{k}$. The final coordinates of the particle is**

(a) (10, 8, 2) (b) (8, 10, 2)
(c) (2, 10, 8) (d) (8, 2, 10)

COMEDK 2020

@apna_pdf

Ans. (a) : Displacement $\Delta\vec{r} = 8\hat{i} - 2\hat{j} + \hat{k}$

Let position vector representing final co-ordinate(x, y, z).

$\vec{r}_f = x\hat{i} + y\hat{j} + z\hat{k}$

$\therefore \Delta\vec{r} = \vec{r}_f - \vec{r}_i$

$$8\hat{i} - 2\hat{j} + \hat{k} = (x\hat{i} + y\hat{j} + z\hat{k}) - (2\hat{i} + 10\hat{j} + \hat{k})$$

$$8\hat{i} - 2\hat{j} + \hat{k} = (x-2)\hat{i} + (y-10)\hat{j} + (z-1)\hat{k}$$

$\therefore \quad x - 2 = 8 \Rightarrow x = 10$

$y - 10 = -2 \Rightarrow y = 8$

$z - 1 = 1 \Rightarrow z = 2$

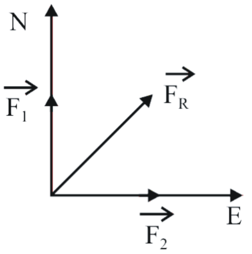
$\vec{r}_f$ final co-ordinates are (10, 8, 2).

72. If two forces of equal magnitudes act simultaneously on a body in the east and the north directions then

(a) the body will displace in the north direction
(b) the body will displace in the east direction
(c) the body will displace in the north-east direction
(d) the body will remain at the rest

AIIMS-2009

Ans. (c) :



Let, the force acting on body $\vec{F}_1$ in north direction and $\vec{F}_2$ in east direction.

$\therefore$ So, the resultant force on the body $\vec{F}_R = \vec{F}_1 + \vec{F}_2$ in North –East direction.

73. Two vectors having equal magnitude of x units acting at an angle of 45° have resultant $\sqrt{\left(2+\sqrt{2}\right)}$ units. The value of x is

(a) 0	(b) 1
(c) $\sqrt{2}$	(d) $2\sqrt{2}$

AIIMS-2009

Ans. (b) : Let two vector is $\vec{A}$ and $\vec{B}$

So, $\vec{A}$ = x units, $\vec{B}$ = x units, θ = 45°, $\vec{R} = \sqrt{\left(2+\sqrt{2}\right)}$

$$\vec{R} = \sqrt{\left(\vec{A}\right)^2 + \left(\vec{B}\right)^2 + 2\vec{A}\vec{B}\cos\theta}$$

$$\sqrt{2+\sqrt{2}} = \sqrt{(x)^2 + (x)^2 + 2.x.x\cos 45°}$$

$$\sqrt{2+\sqrt{2}} = \sqrt{2x^2 + 2x^2 \cdot \frac{1}{\sqrt{2}}}$$

$$\sqrt{2+\sqrt{2}} = \sqrt{2x^2 + \sqrt{2}x^2}$$

Squaring on both side

$$2+\sqrt{2} = 2x^2 + \sqrt{2}x^2$$

$$\left(2+\sqrt{2}\right) = \left(2+\sqrt{2}\right)x^2$$

$$x^2 = \frac{2+\sqrt{2}}{2+\sqrt{2}}$$

$$x^2 = 1$$

x = 1

74. If vectors $\vec{P} = a\hat{i} + a\hat{j} + 3\hat{k}$ and $Q = a\hat{i} - 2\hat{j} - \hat{k}$ are perpendicular to each other, then the positive value of a is

(a) zero	(b) 1
(c) 2	(d) 3

AIIMS-2002
AP EAMCET (Medical)-1998

Ans. (d) : If two vector are perpendicular to each other then their dot product is zero.

$$\vec{P}.\vec{Q} = 0$$

$$\left(a\hat{i} + a\hat{j} + 3\hat{k}\right).\left(a\hat{i} - 2\hat{j} - \hat{k}\right) = 0$$

$a^2 - 2a - 3 = 0$
$a^2 - 3a + a - 3 = 0$
$a(a - 3) + 1(a - 3) = 0$
$(a - 3)(a + 1) = 0$
$a = 3, a = -1$
$a = 3, -1$

So, positive value of a is 3

75. Two equal vectors have a resultant equal to either of them, then the angle between them will be

(a) 110°	(b) 120°
(c) 60°	(d) 150°

AIIMS-2000, BCECE-2007

Ans. (b) : Let the two vector be A and B both at angle of θ from each other with a resultant R

From the triangle law of vector addition,

$R^2 = A^2 + B^2 + 2AB\cos\theta$
A = B = R (given)
$(A)^2 = (A)^2 + (A)^2 + 2.A.A.\cos\theta$
$A^2 = 2A^2(1 + \cos\theta)$

$$\cos\theta = \frac{-1}{2}$$

cosθ = cos120°
θ = 120°

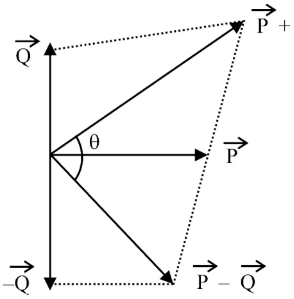
76. The angle between $\left(\vec{P}+\vec{Q}\right)$ and $\left(\vec{P}-\vec{Q}\right)$ will be

(a) 90° only
(b) between 0° and 180°
(c) 180° only
(d) none of these

AIIMS-1999

@apna_pdf

Ans. (b) :



Clearly from figure, angle (θ) between $\left(\vec{P}+\vec{Q}\right)$ and $(\vec{P}-\vec{Q})$ between 0 to 180°.

77. Assertion: If $\left|\vec{A}+\vec{B}\right|=\left|\vec{A}-\vec{B}\right|$, then the angle between $\vec{A}$ and $\vec{B}$ is 90°.

Reason: $\vec{A}+\vec{B}=\vec{B}+\vec{A}$

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-26.05.2019(M) Shift-1

Ans. (b) : Given that, $|\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$

$$\sqrt{A^2+B^2+2AB\cos\theta}=\sqrt{A^2+B^2-2AB\cos\theta}$$

Squaring on both side

$$A^2+B^2+2AB\cos\theta=A^2+B^2-2AB\cos\theta$$
$$A^2+B^2+2AB\cos\theta-A^2-B^2+2AB\cos\theta=0$$
$$4AB\cos\theta=0$$
$$\theta=90°$$

Also, vector addition is cumulative

Hence, $|\vec{A}+\vec{B}|=|\vec{B}+\vec{A}|$

78. If $A=3\hat{i}+4\hat{j}$ and $B=7\hat{i}+24\hat{j}$ then the vector having the same magnitude as B and parallel to A is-

(a) $15\hat{i}+20\hat{j}$
(b) $5\hat{i}-3\hat{j}$
(c) $15\hat{i}+13\hat{j}$
(d) $5\hat{i}+14\hat{j}$

BCECE-2014

Ans. (a) : Given that,

$$\vec{A}=3\hat{i}+4\hat{j} \text{ and } \vec{B}=7\hat{i}+24\hat{j}$$

to get direction we will find unit vector in the direction of $\vec{a}$,

$$\hat{A}=\frac{\vec{A}}{|\vec{A}|}=\frac{3\hat{i}+4\hat{j}}{\sqrt{3^2+4^2}}=\frac{3}{5}\hat{i}+\frac{4}{5}\hat{j}$$

So required vector,

$$|\vec{B}|\hat{A}=\sqrt{7^2+24^2}\left(\frac{3}{5}\hat{i}+\frac{4}{5}\hat{j}\right)$$
$$=\sqrt{625}\left(\frac{3}{5}\hat{i}+\frac{4}{5}\hat{j}\right)=25\times\frac{1}{5}(3\hat{i}+4\hat{j})$$
$$|\vec{B}|\hat{A}=15\hat{i}+20\hat{j}$$

79. The vectors are given by $\vec{A}=\hat{i}+2\hat{j}+2\hat{k}$ and $\vec{B}=3\hat{i}+6\hat{j}+2\hat{k}$. Another vector C has the same magnitude as B but has the same direction as A. Then which of the following vectors represents C?

(a) $\frac{7}{3}\left(\hat{i}+2\hat{j}+2\hat{k}\right)$
(b) $\frac{3}{7}\left(\hat{i}-2\hat{j}+2\hat{k}\right)$
(c) $\frac{7}{9}\left(\hat{i}-2\hat{j}+2\hat{k}\right)$
(d) $\frac{9}{7}\left(\hat{i}+2\hat{j}+2\hat{k}\right)$

WB JEE 2013

Ans. (a) : Given that, $\vec{A}=\hat{i}+2\hat{j}+2\hat{k}$

Magnitude of $|\vec{A}|=\sqrt{1^2+2^2+2^2}=3$

Unit vector along $\vec{A}$.

$$\hat{A}=\frac{\vec{A}}{|\vec{A}|}=\frac{\hat{i}+2\hat{j}+2\hat{k}}{3}$$
$$\vec{B}=3\hat{i}+6\hat{j}+2\hat{k}$$

Magnitude of $|\vec{B}|=\sqrt{3^2+6^2+2^2}$

$$=\sqrt{9+36+4}$$
$$|\vec{B}|=7$$

So, $C=|\vec{B}|\hat{A}$

$$C=7\times\frac{\hat{i}+2\hat{j}+2\hat{k}}{3}$$
$$\boxed{C=\frac{7}{3}\left(\hat{i}+2\hat{j}+2\hat{k}\right)}$$

80. The (x,y,z) coordinates of two points A and B are given respectively as (0,3,–1) and (–2,6,4). The displacement vector form A to B may be given by :

(a) $-2\hat{i}+6\hat{j}+4\hat{k}$
(b) $-2\hat{i}+3\hat{j}+3\hat{k}$
(c) $-2\hat{i}+3\hat{j}+5\hat{k}$
(d) $2\hat{i}-3\hat{j}-5\hat{k}$

BCECE-2006

Ans. (c) : Given,

$$r_A=3\hat{j}-\hat{k}, \qquad r_B=-2\hat{i}+6\hat{j}+4\hat{k}$$

Displacement vector $(r_{AB})=r_B-r_A$.

$$r_{AB}=\left(-2\hat{i}+6\hat{j}+4\hat{k}\right)-\left(3\hat{j}-\hat{k}\right)$$
$$r_{AB}=-2\hat{i}+3\hat{j}+5\hat{k}$$

Therefore, the displacement vector from A to B is $-2\hat{i}+3\hat{j}+5\hat{k}$

81. The resultant of two forces P and Q is of magnitude P. If P be doubled, the resultant will be inclined to Q at an angle.

(a) 0^0
(b) 30^0
(c) 60^0
(d) 90^0

UPSEE-2016
BCECE-2010

@apna_pdf

Ans. (d) : Let the angle between P and Q be θ.
Since, the resultant of P and Q is P

$\therefore P^2 = P^2 + Q^2 + 2PQ\cos\theta$

$-Q^2 = 2PQ\cos\theta$

$Q = -2P\cos\theta$

According to the question, given P is doubled then

$4P^2 = 4P^2 + Q^2 + 4PQ\cos\theta$

Put the value of Q

$0 = (-2P\cos\theta)^2 + 4P(-2P\cos\theta).\cos\theta$

$0 = 4P^2\cos^2\theta - 8P^2\cos^2\theta$

$0 = -4P^2\cos^2\theta$

$\cos\theta = 0$

$\theta = 90°$

82. If $\vec{a}+\vec{b}=\vec{c}$ and a + b = c, then the angle included between $\vec{a}$ and $\vec{b}$ is

(a) 90° (b) 180°
(c) 120° (d) zero

WB JEE-2010

Ans. (d) : Given that, $\vec{a}+\vec{b}=\vec{c}$ and $a+b=c$

$$|\vec{c}|=|\vec{a}+\vec{b}|$$

$$c^2 = a^2 + b^2 + 2ab\cos\theta$$

$$c=\sqrt{a^2+b^2+2ab\cos\theta}$$

$$a+b=\sqrt{a^2+b^2+2ab\cos\theta}$$

$$a^2 + b^2 + 2ab = a^2 + b^2 + 2ab\cos\theta$$

$$\cos\theta = 1$$

$$\theta = 0^\circ$$

83. Consider the vectors A = $\hat{i}+\hat{j}-\hat{k}$, B = $2\hat{i}-\hat{j}+\hat{k}$ and C = $\frac{1}{\sqrt{5}}(\hat{i}-2\hat{j}+2\hat{k})$. What is the value of C.(A ×B)?

(a) 1 (b) 0
(c) $3\sqrt{2}$ (d) $18\sqrt{5}$

WB JEE 2020

Ans. (b) : Given, $\vec{A}=\hat{i}+\hat{j}-\hat{k},\ \vec{B}=2\hat{i}-\hat{j}+\hat{k}$

$$\vec{C}=\frac{1}{\sqrt{5}}\left(\hat{i}-2\hat{j}+2\hat{k}\right)$$

Now,

$$\vec{A}\times\vec{B}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 1 & -1\\ 2 & -1 & 1\end{vmatrix}$$

$$\vec{A}\times\vec{B}=-3\hat{j}-3\hat{k}$$

According to the question,

$$\vec{C}.\left(\vec{A}\times\vec{B}\right)=\frac{1}{\sqrt{5}}\left(\hat{i}-2\hat{j}+2\hat{k}\right).\left(0\hat{i}-3\hat{j}-3\hat{k}\right)$$

$$=\frac{1}{\sqrt{5}}(6-6)$$

$$=0$$

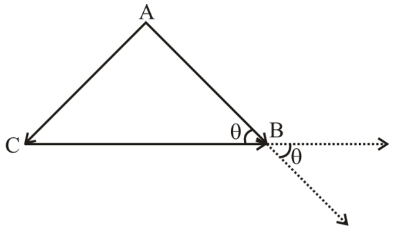
84. In a triangle ABC, the sides AB and AC are represented by the vectors $3\hat{i}+\hat{j}+\hat{k}$ and $\hat{i}+2\hat{j}+\hat{k}$ respectively. Calculate the angle ∠ABC.

(a) $\cos^{-1}\sqrt{\frac{5}{11}}$ (b) $\cos^{-1}\sqrt{\frac{6}{11}}$

(c) $\left(90^\circ-\cos^{-1}\sqrt{\frac{5}{11}}\right)$ (d) $\left(180^\circ-\cos^{-1}\sqrt{\frac{5}{11}}\right)$

WB JEE 2018

Ans. (a) :



Given that, $\overrightarrow{AB}=3\hat{i}+\hat{j}+\hat{k}$, $\overrightarrow{AC}=\hat{i}+2\hat{j}+\hat{k}$

$$\therefore \overrightarrow{CB}=\overrightarrow{AB}-\overrightarrow{AC}$$

$$\overrightarrow{CB}=3\hat{i}+\hat{j}+\hat{k}-(\hat{i}+2\hat{j}+\hat{k})$$

$$\overrightarrow{CB}=2\hat{i}-\hat{j}$$

∠ABC is angle between $\overrightarrow{AB}$ and $\overrightarrow{CB}$

$$\therefore \quad \overrightarrow{AB}\cdot\overrightarrow{CB}=|\overrightarrow{AB}||\overrightarrow{CB}|\cos\theta$$

$$(6-1)=\sqrt{3^2+1^2+1^2}\times\sqrt{(2)^2+(-1)^2}\times\cos\theta$$

$$5=\sqrt{11}\times\sqrt{5}\times\cos\theta$$

$$\cos\theta=\frac{5}{\sqrt{11}\times\sqrt{5}}$$

$$\cos\theta=\frac{\sqrt{5}}{\sqrt{11}}$$

$$\theta=\cos^{-1}\left(\frac{\sqrt{5}}{\sqrt{11}}\right)$$

85. Three vectors A = $a\hat{i}+\hat{j}+\hat{k}$; B = $\hat{i}+b\hat{j}+\hat{k}$ and C = $\hat{i}+\hat{j}+c\hat{k}$ are mutually perpendicular ($\hat{i},\hat{j}$ and $\hat{k}$ are unit vectors along X, Y and Z- axis respectively). The respective values of *a*, b and c are

(a) 0, 0, 0 (b) $-\frac{1}{2},-\frac{1}{2},-\frac{1}{2}$

(c) 1, –1, 1 (d) $\frac{1}{2},\frac{1}{2},\frac{1}{2}$

WB JEE 2017

Ans. (b) : Given that, A = $a\hat{i}+\hat{j}+\hat{k}$, B = $\hat{i}+b\hat{j}+\hat{k}$, C = $\hat{i}+\hat{j}+c\hat{k}$ are mutually perpendicular–

So, A.B = 0
B. C = 0
A. C = 0

Now, $a + b + 1 = 0$ …… (i)

@apna_pdf

$1 + b + c = 0$ …… (ii)

$a + 1 + c = 0$ .....(iii)

On adding equation (i), (ii) and (iii), we get–

$2(a + b + c) = -3$

$\Rightarrow \quad a + b + c = -3/2$ ….. (iv)

By equation (i) and (iv) we get–

$-1 + c = -3/2$

$c = -1/2$

Similarly, $b = -1/2$

$a = -1/2$

86. If A = B + C have scalar magnitudes of 5, 4, 3 units respectively, then the angle between A and C is

(a) $\cos^{-1}(3/5)$

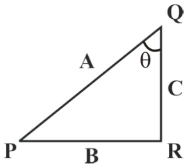
(b) $\cos^{-1}(4/5)$

(c) $\pi/2$

(d) $\sin^{-1}(3/4)$

WB JEE 2012

Ans. (a) : Here, triangle PQR is a given with vector. A, B, C are its adjacent sides.



5, 4 and 3 makes the triangle right angle triangle.

$$\cos\theta = \frac{QR}{PQ}$$

$$\theta = \cos^{-1}\left(\frac{|C|}{|A|}\right)$$

$$\theta = \cos^{-1}\left(\frac{3}{5}\right)$$

87. The magnitudes of vectors A, B and C are 3, 4 and 5 units respectively. If A+B = C, the angle between A and B is

(a) $\frac{\pi}{2}$

(b) $\cos^{-1}(0.6)$

(c) $\tan-1\left(\frac{7}{5}\right)$

(d) $\frac{\pi}{4}$

[AIPMT 1988]

Ans. (a) : Given that, $\vec{A} = 3,\ \vec{B} = 4,\ \vec{C} = 5$

Let θ be the angle between them

$$\vec{A} + \vec{B} = \vec{C}$$

Squaring on both side

$$\left|\vec{A}\right|^2 + \left|\vec{B}\right|^2 + 2\vec{A}\vec{B} = \left|\vec{C}\right|^2$$

$$\left|\vec{A}\right|^2 + \left|\vec{B}\right|^2 + 2\left|\vec{A}\right|\left|\vec{B}\right|\cos\theta = \left|\vec{C}\right|^2 \quad \text{…(i)}$$

On putting the value, we get–

$(3)^2 + (4)^2 + 2\times 3\times 4\cos\theta = (5)^2$

$25 + 24\cos\theta = 25$

$\cos\theta = 0$

$$\boxed{\theta = \frac{\pi}{2}}$$

88. Given $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = \hat{i} + \hat{j}$. The component of vector $\vec{A}$ along vector $\vec{B}$ is

(a) $\frac{1}{\sqrt{2}}$

(b) $\frac{3}{\sqrt{2}}$

(c) $\frac{5}{\sqrt{2}}$

(d) $\frac{7}{\sqrt{2}}$

HPCET-2018

WB JEE 2011, 2009

Ans. (c) : Given that, $\vec{A} = 2\hat{i} + 3\hat{j},\ B = \hat{i} + \hat{j}$

$$|\vec{B}| = \sqrt{1^2 + 1^2} = \sqrt{2}$$

$$\vec{A}\cdot\vec{B} = \left(2\hat{i} + 3\hat{j}\right)\left(\hat{i} + \hat{j}\right) = 2 + 3 = 5$$

Component of vector $\vec{A}$ along vector $\vec{B}$ would be

$$= \frac{\vec{A}\cdot\vec{B}}{|\vec{B}|} = \frac{5}{\sqrt{2}}$$

89. Given $\vec{C} = \vec{A}\times\vec{B}$ and $\vec{D} = \vec{B}\times\vec{A}$. What is the angle between $\vec{C}$ and $\vec{D}$?

(a) 30°

(b) 60°

(c) 90°

(d) 180°

WB JEE 2009

Ans. (d) : Given, $\vec{C} = \vec{A}\times\vec{B}$, $\vec{D} = \vec{B}\times\vec{A}$

$\vec{C}$ and $\vec{D}$ are anti parallel so, $\vec{A}\times\vec{B} = -\left(\vec{B}\times\vec{A}\right)$

So, angle between $\vec{C}$ and $\vec{D}$ is 180º.

90. The angle subtended by the vector $A = 4\hat{i} + 3\hat{j} + 12\hat{k}$ with x-axis is

(a) $\sin^{-1}\left(\frac{3}{13}\right)$

(b) $\sin^{-1}\left(\frac{4}{13}\right)$

(c) $\cos^{-1}\left(\frac{4}{13}\right)$

(d) $\cos^{-1}\left(\frac{3}{13}\right)$

WB JEE 2008

Ans. (c) : Given that,

$\vec{A} = 4\hat{i} + 3\hat{j} + 12\hat{k}$

Angle with x-axis

$$\cos\theta = \frac{A_x}{|\vec{A}|}$$

$$\cos\theta = \frac{4}{\sqrt{(4)^2 + (3)^2 + (12)^2}}$$

$$\cos\theta = \frac{4}{13}$$

$$\theta = \cos^{-1}\left(\frac{4}{13}\right)$$

91. Which of the following is a vector quantity?

(a) Temperature

(b) Flux density

(c) Magnetic field intensity

(d) Time

WB JEE-2007

@apna_pdf

Ans. (c) : Time and temperature have only magnitude so they are scalar. The flux density is the dot product of the field and the area vector so it is also scalar. Magnetic field intensity (H) has both direction and magnitude so it is a vector quantity.

92. **If a_1 and a_2 are two non-collinear unit vectors and if $|a_1 + a_2| = \sqrt{3}$,**
Then the value of $(a_1 - a_2) . (2a_1 + a_2)$ is

(a) 2 (b) $\sqrt{3}$

(c) $\frac{1}{2}$ (d) $\vec{a}_1$, and $\vec{a}_2$ 1

UP CPMT-2009

Ans. (c) : Given that, $|a_1 + a_2| = \sqrt{3}$

$\vec{a}_1$ and $\vec{a}_2$ are non-collinear vector

$\therefore \ |\vec{a}_1| = |\vec{a}_2| = 1$

Let the angle between a_1 and a_2 is θ

$a_1^2 + a_2^2 + 2a_1a_2\cos\theta = \left(\sqrt{3}\right)^2$

$1 + 1 + 2\cos\theta = 3$

$2\cos\theta = 3 - 2$

$2\cos\theta = 1$

$\cos\theta = \frac{1}{2}$

Now,

$= (a_1 - a_2) . (2a_1 + a_2)$

$= 2a_1^2 - 2(a_1 \cdot a_2) + (a_1 \cdot a_2) - a_2^2$

$= 2a_1^2 - (a_1 \cdot a_2) - a_2^2$

Putting the value of $a_1 = 1$ and $a_2 = 1$ and $\cos\theta = 1/2$

$= 2a_1^2 - a_2^2 - a_1 a_2 \cos\theta$

$= 2 - 1 - \frac{1}{2}$

$(a_1 - a_2) . (2a_1 + a_2) = 1 - \frac{1}{2}$

$(a_1 - a_2) . (2a_1 + a_2) = \frac{1}{2}$

93. **Two vectors are perpendicular, if**

(a) $\vec{A}\cdot\vec{B} = 1$ (b) $\vec{A}\times\vec{B} = 0$

(c) $\vec{A}\cdot\vec{B} = 0$ (d) $\vec{A}\times\vec{B} = \vec{A}\vec{B}$

UP CPMT-2007

Ans. (c) : We know that,

$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

$\vec{A}.\vec{B} = |\vec{A}||\vec{B}|\cos 90°$

$\therefore \quad \vec{A}.\vec{B} = 0 \qquad (\because \cos 90° = 0)$

Hence, two vector are perpendicular if their dot product is equal to zero.

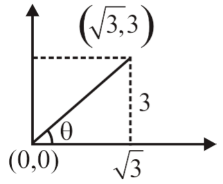
94. **A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are $\left(\sqrt{3}, 3\right)$ The path of the particle makes with the x-axis an angle of**

(a) 30° (b) 45°

(c) 60° (d) 0°

UP CPMT-2008
JIPMER - 2009

Ans. (c) : Let, θ be the angle that particle makes with x-axis.



$\tan\theta = \frac{y}{x} = \frac{3}{\sqrt{3}} = \sqrt{3}$

$\theta = \tan^{-1}\sqrt{3}$

$\theta = 60°$

95. **Find the torque of a force $F = -3\hat{i} + 2\hat{j} + 1\hat{k}$ acting at the point $r = 8\hat{i} + 2\hat{j} + 3\hat{k}$.**

(a) $14\hat{i} - 38\hat{j} + 16\hat{k}$ (b) $4\hat{i} + 4\hat{j} + 6\hat{k}$

(c) $-14\hat{i} + 38\hat{j} - 16\hat{k}$ (d) $-4\hat{i} - 17\hat{j} + 22\hat{k}$

UP CPMT-2010

Ans. (d) : Torque of the force

$\vec{\tau} = \vec{r} \times \vec{F}$

$$\tau = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 8 & 2 & 3 \\ -3 & 2 & 1 \end{vmatrix}$$

$= \hat{i}(2-6) - \hat{j}(8+9) + \hat{k}(16+6)$

$= -4\hat{i} - 17\hat{j} + 22\hat{k}$

96. **If force $F = 5\hat{i} + 3\hat{j} + 4\hat{k}$ makes a displacement of $s = 6\hat{i} - 5\hat{k}$ work done by the force is**

(a) 10 units (b) $122\sqrt{5}$ units

(c) $5\sqrt{122}$ units (d) 20 units

UP CPMT-2003

Ans. (a) : Given that,

Force (F) = $5\hat{i} + 3\hat{j} + 4\hat{k}$

Displacement (s) = $6\hat{i} - 5\hat{k}$

The work done is given by the following relation.

$W = \vec{F}.\vec{d}$

$W = \left(5\hat{i} + 3\hat{j} + 4\hat{k}\right).\left(6\hat{i} - 5\hat{k}\right)$

$W = \left(5\hat{i} + 3\hat{j} + 4\hat{k}\right).\left(6\hat{i} + 0\hat{j} - 5\hat{k}\right)$

$W = 30 + 0 - 20$

$W = 10$ units

@apna_pdf

97. A body is rotating with angular velocity $\omega = (3\hat{i} - 4\hat{j} + \hat{k})$. The linear velocity of a point having position vector $r = (5\hat{i} - 6\hat{j} + 6\hat{k})$ is

(a) $6\hat{i} + 2\hat{j} - 3\hat{k}$ (b) $18\hat{i} + 13\hat{j} - 2\hat{k}$

(c) $-18\hat{i} - 13\hat{j} + 2\hat{k}$ (d) $6\hat{i} - 2\hat{j} + 8\hat{k}$

UP CPMT-2001

Ans. (c) : Given that,

$$\omega = (3\hat{i} - 4\hat{j} + \hat{k})$$

$$r = (5\hat{i} - 6\hat{j} + 6\hat{k})$$

We know that

$$\text{Linear velocity (v)} = \ = \vec{\omega} \times \vec{r} = \left(\vec{\omega} \times \vec{r}\right)$$

$$v = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -4 & 1 \\ 5 & -6 & 6 \end{vmatrix}$$

$$v = \hat{i}(-24 + 6) - \hat{j}(18 - 5) + \hat{k}(-18 + 20)$$

$$v = -18\hat{i} - 13\hat{j} + 2\hat{k}$$

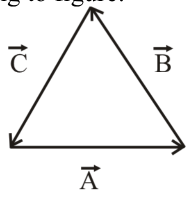
98. The vectors $\vec{A}, \vec{B}$ and $\vec{C}$ are such that $|\vec{A}| = |\vec{B}|, |\vec{C}| = \sqrt{2}|\vec{A}|$ and $\vec{A} + \vec{B} + \vec{C} = 0$. The angles between $\vec{A}$ and $\vec{B}, \vec{B}$ and $\vec{C}$ respectively are

(a) $45^\circ, 90^\circ$ (b) $90^\circ, 135^\circ$

(c) $90^\circ, 45^\circ$ (d) $45^\circ, 135^\circ$

TS EAMCET(Medical)-2015

Ans. (b) : According to figure.



Given that, $\vec{A} + \vec{B} = -\vec{C}$

$$|\vec{A} + \vec{B}| = |-\vec{C}| = |\vec{C}|$$

Squaring both side, we get–

$$|\vec{A} + \vec{B}|^2 = |\vec{C}|^2$$

$$(\vec{A} + \vec{B}) \cdot (\vec{A} + \vec{B}) = |\vec{C}|^2 \qquad \left(\because \ \vec{C} \cdot \vec{C} = |\vec{C}|^2\right)$$

$$\vec{A} \cdot \vec{A} + \vec{A} \cdot \vec{B} + \vec{B} \cdot \vec{A} + \vec{B} \cdot \vec{B} = |\vec{C}|^2$$

$$|\vec{A}|^2 + |\vec{A}||\vec{B}|\cos\theta + |\vec{A}||\vec{B}|\cos\theta + |\vec{B}|^2 = |\vec{C}|^2$$

$$(\because B = A, \ \ C = \sqrt{2}\ A)$$

$$A^2 + A^2\cos\theta + A^2\cos\theta + A^2 = 2A^2$$

$\Rightarrow$ $(2 + 2\cos\theta) = 2$

$\Rightarrow$ $\cos\theta = 0$

$\Rightarrow$ $\theta = 90^\circ$

$$\vec{A} + \vec{B} = -\vec{C}$$

$$\vec{A} \cdot \vec{B} + \vec{B} \cdot \vec{B} = -\vec{B} \cdot \vec{C}$$

$$|\vec{A}||\vec{B}|\cos 90^\circ + B^2 = -|\vec{B}||\vec{C}|\cos\phi$$

$\because$ $A = B, \ C = \sqrt{2}A = \sqrt{2}B$

$$B^2 = -B \cdot \sqrt{2}B \cdot \cos\phi$$

$$\cos\phi = \frac{-1}{\sqrt{2}}$$

$$\boxed{\phi = 135^\circ}$$

So, $\theta = 90^\circ$, $\phi = 135^\circ$

99. An ant starts from the origin and crawls 10 cm along the x – axis and then 20 cm along the y – axis. The dot product of the ant's displacement vector with the position vector of a point that makes 45° with the x – axis and has a magnitude of $\sqrt{2}$ cm is

(a) 30 cm (b) $30\sqrt{2}$ cm

(c) $\frac{30}{\sqrt{2}}$ cm (d) 15 cm

TS EAMCET 18.07.2022, Shift-I

Ans. (a) : Displacement vector of ants = $10\hat{i} + 20\hat{j}$

Position vector of point = $\sqrt{2}$ $(\cos45^\circ\,\hat{i} + \sin45^\circ\,\hat{j})$

Position vector of point = $\hat{i} + \hat{j}$

Cross product of Ant displacement and position vector

$$= (10\,\hat{i} + 20\,\hat{j}).(\hat{i} + \hat{j})$$

$$= (10 + 20)$$

$$= 30 \text{ cm}$$

100. A vector is given as $\vec{A} = 4\hat{i} + 7\hat{j}$. What would be the angle, the vector $\vec{A}$ makes with y – axis

(a) $\theta = \cos^{-1}\left(\frac{7}{\sqrt{11}}\right)$ (b) $\theta = \cos^{-1}\left(\frac{4}{\sqrt{11}}\right)$

(c) $\theta = \cos^{-1}\left(\frac{7}{\sqrt{65}}\right)$ (d) $\theta = \cos^{-1}\left(\frac{4}{\sqrt{65}}\right)$

TS EAMCET 30.07.2022, Shift-I

Ans. (c) : Given, $\vec{A} = 4\hat{i} + 7\hat{j}$, $\vec{B} = \hat{j}$ (y-axis)

We know that,

$$\cos\theta = \frac{\vec{A} \cdot \vec{B}}{|\vec{A}||\vec{B}|} = \frac{(4\hat{i} + 7\hat{j}) \cdot \hat{j}}{\sqrt{4^2 + 7^2}\sqrt{1^2}}$$

$$\theta = \cos^{-1}\left(\frac{7}{\sqrt{65}}\right)$$

101. The resultant of the two vectors $\vec{A}$ and $\vec{B}$ makes angle α with $\vec{A}$ and β with $\vec{B}$.

Statement (A) : $\alpha < \beta$ if $|\vec{A}| < |\vec{B}|$

Statement (B) : $\alpha < \beta$ if $|\vec{A}| > |\vec{B}|$

Statement (C) : $\alpha = \beta$ if $|\vec{A}| = |\vec{B}|$

@apna_pdf

(a) (A) and (C) are true
(b) Only (C) is true
(c) (B) and (C) are true
(d) (A),(B),(C) are all true

TS EAMCET 08.05.2019, Shift-I

Ans. (c) : $\vec{A} = \vec{R}\cos\alpha$

$\vec{B} = \vec{R}\cos\beta$

Suppose that $\alpha < \beta$

Then, $\cos\alpha > \cos\beta$, So $|\vec{A}| > |\vec{B}|$

And suppose that $\alpha = \beta$

Then, $\cos\alpha = \cos\beta$, So $|\vec{A}| = |\vec{B}|$

102. Vector $\vec{a} = \hat{i} + 2\hat{j} + 2\hat{k}$ and $\vec{b} = \hat{i} - \hat{j} + \hat{k}$. What is the unit vector along $\vec{a} + \vec{b}$?

(a) $\frac{2\hat{i} + \hat{j} + 3\hat{k}}{\sqrt{14}}$
(b) $\frac{2\hat{i} - \hat{j} + 4\hat{k}}{\sqrt{20}}$
(c) $\frac{2\hat{i} + \hat{j} + 3\hat{k}}{\sqrt{13}}$
(d) $\frac{2\hat{i} + \hat{j} - 3\hat{k}}{\sqrt{10}}$

TS EAMCET 28.09.2020, Shift-I

Ans. (a) : Given that, $\vec{a} = \hat{i} + 2\hat{j} + 2\hat{k}$, $\vec{b} = \hat{i} - \hat{j} + \hat{k}$

$$\vec{a} + \vec{b} = (\hat{i} + 2\hat{j} + 2\hat{k}) + (\hat{i} - \hat{j} + \hat{k})$$

$$\vec{a} + \vec{b} = 2\hat{i} + \hat{j} + 3\hat{k}$$

$$\text{Unit vector of } (\vec{a} + \vec{b}) = \frac{\vec{a} + \vec{b}}{|\vec{a} + \vec{b}|}$$

$$= \frac{(2\hat{i} + \hat{j} + 3\hat{k})}{\sqrt{4+1+9}} = \frac{2\hat{i} + \hat{j} + 3\hat{k}}{\sqrt{14}}$$

103. Find the angle between the two vectors: $\vec{a} = 3\hat{i} + 2\hat{j} + 5\hat{k}, \vec{b} = 5\hat{i} + 3\hat{j} + \hat{k}$

(a) $\cos^{-1}\left(\frac{26}{\sqrt{1330}}\right)$
(b) $\sin^{-1}\left(\frac{26}{\sqrt{1330}}\right)$
(c) $\cos^{-1}\left(\frac{26}{\sqrt{1335}}\right)$
(d) $\tan^{-1}\left(\frac{26}{\sqrt{1330}}\right)$

TS EAMCET 04.08.2021, Shift-I

Ans. (a) : Given, $\vec{a} = 3\hat{i} + 2\hat{j} + 5\hat{k}, \vec{b} = 5\hat{i} + 3\hat{j} + \hat{k}$

$$|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2} = \sqrt{(3)^2 + (2)^2 + (5)^2} = \sqrt{38}$$

$$|\vec{b}| = \sqrt{b_x^2 + b_y^2 + b_z^2} = \sqrt{(5)^2 + (3)^2 + (1)^2} = \sqrt{35}$$

$$\vec{a}.\vec{b} = (3\hat{i} + 2\hat{j} + 5\hat{k}) \cdot (5\hat{i} + 3\hat{j} + \hat{k})$$

$$= 15+6+5 = 26$$

$$\vec{a}.\vec{b} = ab\cos\theta$$

$$\cos\theta = \frac{\vec{a}.\vec{b}}{|\vec{a}||\vec{b}|} = \frac{26}{\sqrt{38}\sqrt{35}} = \frac{26}{\sqrt{1330}}$$

$$\theta = \cos^{-1}\frac{26}{\sqrt{1330}}$$

So, Angle between two vector is $\cos^{-1}\left(\frac{26}{\sqrt{1330}}\right)$

104. Find the component of vector $\vec{P} = 2\hat{i} + 3\hat{j}$ along the direction of vector $\vec{Q} = \hat{i} + \hat{j}$.

(a) 2
(b) $2\sqrt{5}$
(c) $\frac{5}{\sqrt{2}}$
(d) $\frac{\sqrt{2}}{5}$

TS EAMCET 04.08.2021, Shift-II
HP CET-2018

Ans. (c) :

$$\text{Projection of } \vec{P} \text{ on } \vec{Q} = \frac{\vec{P}.\vec{Q}}{|\vec{Q}|}$$

$$= \frac{(2i + 3j)(i + j)}{\sqrt{2}} = \frac{2+3}{\sqrt{2}} = \frac{5}{\sqrt{2}}$$

105. The y-component of vector $\vec{A}$ is +3.0 m if $\vec{A}$ makes an angle of 30° counter clockwise from the positive y - axis, the magnitude of $\vec{A}$ is (assume $\vec{A}$ is in x - y plane)

(a) $2\sqrt{3}$m
(b) $\sqrt{11}$m
(c) $\sqrt{15}$m
(d) $\sqrt{21}$m

TS EAMCET 04.08.2021, Shift-II

Ans. (a) : y - component of vector $\vec{A}$ = + 3

$\vec{A}$ makes an angle of 30° counter clockwise from the positive y - axis the magnitude of A is,

$$A = \frac{\vec{A}_y}{\cos 30^\circ}$$

$$A = \frac{+3}{\cos 30^\circ} = \frac{3}{\frac{\sqrt{3}}{2}} = \frac{\sqrt{3} \times \sqrt{3}}{\sqrt{3}/2} = 2\sqrt{3}$$

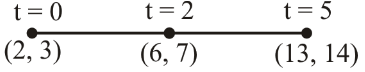
$$\boxed{A = 2\sqrt{3}\text{m}}$$

106. A particle is moving such that its position co-ordinates (x, y) are (2m, 3m) at time t = 0, (6m, 7m) at time t = 2 s and (13m, 14m) at time t = 5 s. Average velocity vector (v_{av}) from t = 0 to t = 5 s is

(a) $\frac{1}{5}\left(13\hat{i} + 14\hat{j}\right)$
(b) $\frac{7}{3}\left(\hat{i} + \hat{j}\right)$
(c) $2\left(\hat{i} + \hat{j}\right)$
(d) $\frac{11}{5}\left(\hat{i} + \hat{j}\right)$

[AIPMT 2014]

Ans. (d) : According to figure,



It is given that, t = 0 to t = 5 sec

$$\vec{v}_{avg} = \frac{\text{displacement}}{\text{time}}$$

$$\frac{(\vec{r}_C - \vec{r}_A)}{(5-0)} = \frac{\left(13\hat{i} + 14\hat{j}\right) - \left(2\hat{i} + 3\hat{j}\right)}{5} = \frac{11\hat{i} + 11\hat{j}}{5}$$

$$\vec{v}_{avg} = \frac{11}{5}\left(\hat{i} + \hat{j}\right)$$

@apna_pdf

107. If the magnitude of sum of two vectors is equal to the magnitude of difference of the two vectors, the angle between these vectors is

(a) 90° (b) 45°

(c) 180° (d) 0°

[NEET 2016, AIPMT 1991]

Ans. (a) : There are two vectors A and B

It is given that,

$$|A+B| = |A-B|$$

Let, angle between A and B is ϕ

$$A^2 + B^2 + 2AB\cos\phi = A^2 + B^2 - 2AB\cos\phi$$

$$\cos\phi = 0 \; [\because A, B \neq 0]$$

$$\phi = \frac{\pi}{2} = 90^\circ$$

108. If vectors $\mathbf{A = \cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}}$ and $\mathbf{B = \cos\frac{\omega t}{2}\hat{i} + \sin\frac{\omega t}{2}\hat{j}}$ are functions of time, then the value of t at which they are orthogonal to each other, is

(a) $t = \frac{\pi}{4\omega}$ (b) $t = \frac{\pi}{2\omega}$

(c) $t = \frac{\pi}{\omega}$ (d) $t = 0$

[AIPMT 2015]

Ans. (c) : Given, $\vec{A} = \cos\omega t\hat{i} + \sin\omega t\hat{j}$

$$\vec{B} = \cos\frac{\omega t}{2}\hat{i} + \sin\frac{\omega t}{2}\hat{j}$$

If two vector are orthogonal then their dot product will be zero–

$$\vec{A}\cdot\vec{B} = 0$$

$$\left(\cos\omega t\hat{i} + \sin\omega t\hat{j}\right)\cdot\left(\cos\frac{\omega t}{2}\hat{i} + \sin\frac{\omega t}{2}\hat{j}\right) = 0$$

$$\cos\omega t\cdot\cos\frac{\omega t}{2} + \sin\omega t\cdot\sin\frac{\omega t}{2} = 0$$

$$\cos\left(\omega t - \frac{\omega t}{2}\right) = 0$$

$$[\because \cos A\cos B + \sin A\sin B = \cos(A-B)]$$

$$\cos\left(\omega t - \frac{\omega t}{2}\right) = \cos\frac{\pi}{2}$$

$$\omega t - \frac{\omega t}{2} = \frac{\pi}{2}$$

$$\frac{\omega t}{2} = \frac{\pi}{2} \text{ or } t = \frac{\pi}{\omega}$$

109. A and B are two vectors and θ is the angle between them. If $\mathbf{|\vec{A}\times\vec{B}| = \sqrt{3}\left(\vec{A}.\vec{B}\right)}$, then the value of θ is

(a) 60° (b) 30°

(c) 30° (d) 90°

[AIPMT 2007]

Ans. (a) : $|A\times B| = \sqrt{3}\,(A.B)$

$$AB\sin\theta = \sqrt{3}\,AB\cos\theta$$

$$\tan\theta = \sqrt{3}$$

$$\theta = \tan^{-1}(\sqrt{3})$$

$$\theta = 60^\circ$$

110. If $\mathbf{|\vec{A}\times\vec{B}| = \sqrt{3}\vec{A}.\vec{B}}$ then the value of $\mathbf{|A+B|}$ is

(a) $(A^2 + B^2 + AB)^{1/2}$

(b) $\left(A^2 + B^2 + \frac{AB}{\sqrt{3}}\right)^{1/2}$

(c) $A + B$

(d) $\left(A^2 + B^2 + \sqrt{3}AB\right)^{1/2}$

BCECE-2013
UPSEE - 2006
[AIPMT 2004]

Ans. (a) : Given that, $|\vec{A}\times\vec{B}| = \sqrt{3}\vec{A}.\vec{B}$

$$AB\sin\theta = \sqrt{3}\,AB\cos\theta$$

$$\tan\theta = \sqrt{3}$$

$$\theta = 60^\circ$$

We know that,

Law of parallelogram of addition

$$|\vec{A}+\vec{B}| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$|\vec{A}+\vec{B}| = \sqrt{A^2 + B^2 + 2AB\times\frac{1}{2}}$$

$$|\vec{A}+\vec{B}| = (A^2 + B^2 + AB)^{1/2}$$

111. If a vector $\mathbf{2\hat{i} + 3\hat{j} + 8\hat{k}}$ is perpendicular to the vector $\mathbf{4\hat{j} - 4\hat{i} + \alpha\hat{k}}$, then the value of α is

(a) -1 (b) $\frac{1}{2}$

(c) $-\frac{1}{2}$ (d) 1

Karnataka CET-2017
JIPMER-2007
AIPMT-2005

Ans. (c) : Given, $\vec{a} = 2\hat{i} + 3\hat{j} + 8\hat{k}$, $\vec{b} = -4\hat{i} + 4\hat{j} + \alpha\hat{k}$

$\vec{a}$ and $\vec{b}$ are perpendicular so,

$$\vec{a}.\vec{b} = 0$$

$$\left(2\hat{i} + 3\hat{j} + 8\hat{k}\right)\cdot\left(-4\hat{i} + 4\hat{j} + \alpha\hat{k}\right) = 0$$

$$-8 + 12 + 8\alpha = 0$$

$$4 + 8\alpha = 0$$

$$8\alpha = -4$$

$$\alpha = -\frac{1}{2}$$

@apna_pdf

112. If a unit vector is represented by $0.5\hat{i}+0.8\hat{j}+c\hat{k}$, then the value of c is

(a) 1 (b) $\sqrt{0.11}$

(c) $\sqrt{0.01}$ (d) 0.39

TS EAMCET (Medical)-2017

[AIPMT 1999]

Ans. (b) : Given, $\vec{A}=0.5\hat{i}+0.8\hat{j}+c\hat{k}$

It is unit vector so it has magnitude

$$|\vec{A}|=1$$

$$\sqrt{(0.5)^2+(0.8)^2+c^2}=1$$

$$c^2=0.11$$

$$c=\sqrt{0.11}$$

113. Which of the following is not a vector quantity?

(a) Speed (b) Velocity

(c) Torque (d) Displacement

[AIPMT 1995]

Ans. (a) : The physical quantities for which having both direction and magnitude is called vector quantity.

Example- force, torque, momentum, acceleration velocity etc.

114. The angle between the two vectors $A=3\hat{i}+4\hat{j}+5\hat{k}$ and $B=3\hat{i}+4\hat{j}-5\hat{k}$ will be

(a) 0° (b) 45°

(c) 90° (d) 180°

[AIPMT 1994]

Ans. (c) : Given,

$$\vec{A}=3\hat{i}+4\hat{j}+5\hat{k} \text{ and } \vec{B}=3\hat{i}+4\hat{j}-5\hat{k}$$

$$\cos\theta=\frac{\vec{A}.\vec{B}}{|A||B|}$$

$$\cos\theta=\frac{(3\hat{i}+4\hat{j}+5\hat{k})(3\hat{i}+4\hat{j}-5\hat{k})}{\sqrt{(3)^2+(4)^2+(5)^2}\sqrt{(3)^2+(4)^2+(5)^2}}$$

$$\cos\theta=\frac{9+16-25}{\sqrt{(3)^2+(4)^2+(5)^2}.\sqrt{(3)^2+(4)^2+(5)^2}}$$

$$\cos\theta=\frac{0}{50}$$

$$\cos\theta=0$$

$$\cos\theta=\cos 90°$$

$$\theta=90°$$

115. The angle between $\vec{A}$ and $\vec{B}$ is θ. The value of the triple product $\vec{A}.(\vec{B}\times\vec{A})$ is

(a) A^2B (b) zero

(c) $A^2B\sin\theta$ (d) $A^2B\cos\theta$

JIPMER-2007

AIPMT-1989

Ans. (b) : Let $\vec{A}\cdot(\vec{B}\times\vec{A})=\vec{A}\cdot\vec{C}$

Here $\vec{C}=\vec{B}\times\vec{A}$ which is perpendicular to both vector $\vec{A}$ and $\vec{B}$.

$\therefore$ $\vec{A}\cdot\vec{C}=0$

$\because$ $\vec{C}$ is perpendicular to $\vec{A}$ and $\vec{B}$

$\therefore$ Angle between $\vec{A}$ and $\vec{C}$ is 90°

$$\vec{A}\cdot\vec{C}=AC\cos\theta$$

$$\vec{A}\cdot\vec{C}=0$$

$\therefore$ $\vec{A}\cdot(\vec{B}\times\vec{A})=0$

116. If $\vec{A}=(2\hat{i}+3\hat{j}-\hat{k})$m and $\vec{B}=(\hat{i}+2\hat{j}+2\hat{k})$m. The magnitude of component of vector $\hat{A}$ along vector $\hat{B}$ will be ———— m.

JEE Main-26.07.2022, Shift-II

Ans. (2) : $\vec{A}=2\hat{i}+3\hat{j}-\hat{k}$ and $\vec{B}=(\hat{i}+2\hat{j}+2\hat{k})$

Magnitude of $\vec{A}$ along $\vec{B}=\dfrac{\vec{A}\cdot\vec{B}}{|\vec{B}|}$

$$\frac{(2\hat{i}+3\hat{j}-\hat{k})(\hat{i}+2\hat{j}+2\hat{k})}{\sqrt{(1)^2+(2)^2+(2)^2}}$$

$$\frac{2+6-2}{\sqrt{9}}=\frac{6}{3}=2$$

117. $\vec{A}$ is a vector quantity such that $|\vec{A}|$ = non-zero constant. Which of the following expression is true for $\vec{A}$?

(a) $\vec{A}\cdot\vec{A}=0$ (b) $\vec{A}\times\vec{A}<0$

(c) $\vec{A}\times\vec{A}=0$ (d) $\vec{A}\times\vec{A}>0$

JEE Main-25.06.2022, Shift-I

Ans. (c) : Given that, $|\vec{A}|\neq 0$

$$\vec{A}\times\vec{A}=|\vec{A}||\vec{A}|\sin 0°\hat{n}=0$$

So, $\vec{A}\times\vec{A}=0$

118. Which of the following relations is true for two unit vector $\hat{A}$ and $\hat{B}$ making an angle θ to each other ?

(a) $|\hat{A}+\hat{B}|=|\hat{A}-\hat{B}|\tan\frac{\theta}{2}$

(b) $|\hat{A}-\hat{B}|=|\hat{A}+\hat{B}|\tan\frac{\theta}{2}$

(c) $|\hat{A}+\hat{B}|=|\hat{A}-\hat{B}|\cos\frac{\theta}{2}$

(d) $|\hat{A}-\hat{B}|=|\hat{A}+\hat{B}|\cos\frac{\theta}{2}$

JEE Main-25.06.2022, Shift-I

@apna_pdf

Ans. (b) : Given that,

$$|\hat{A}+\hat{B}| = \sqrt{|\hat{A}|^2+|\hat{B}|^2+2|\hat{A}||\hat{B}|\cos\theta}$$

$$|\hat{A}|=1 \qquad |\hat{B}|=1$$

$$|\hat{A}+\hat{B}|=\sqrt{(1)^2+(1)^2+2\cos\theta}$$

$$=\sqrt{2+2\cos\theta}$$

$$=\sqrt{2+2\left(2\cos^2\frac{\theta}{2}-1\right)}$$

$$=\sqrt{2\left(1+2\cos^2\frac{\theta}{2}-1\right)}=2\cos\frac{\theta}{2}$$

$$\hat{A}+\hat{B}=2\cos\frac{\theta}{2} \qquad .....(i)$$

$$|\hat{A}-\hat{B}|=\sqrt{|\hat{A}|^2+|\hat{B}|^2-2|\hat{A}||\hat{B}|\cos\theta}$$

$$|\hat{A}-\hat{B}|=\sqrt{1+1-2\cos\theta}$$

$$|\hat{A}-\hat{B}|=\sqrt{2-2\cos\theta}$$

$$=\sqrt{2(1-\cos\theta)}$$

$$=\sqrt{2(1-\left(1-2\sin^2\frac{\theta}{2}\right)}$$

$$=\sqrt{2\left(1-1+2\sin^2\frac{\theta}{2}\right)}$$

$$=\sqrt{2\left(1-1+2\sin^2\frac{\theta}{2}\right)}=2\sin\frac{\theta}{2}$$

$$\hat{A}-\hat{B}=2\sin\frac{\theta}{2} \qquad .....(ii)$$

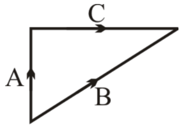
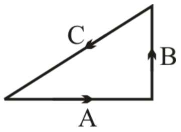
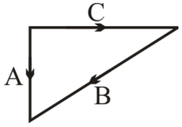
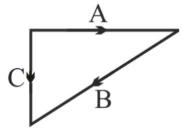
Equation (i) divide by equation (ii), we get –

$$\frac{|\hat{A}-\hat{B}|}{|\hat{A}+\hat{B}|}=\frac{2\sin\frac{\theta}{2}}{2\cos\frac{\theta}{2}}$$

$$\frac{|\hat{A}-\hat{B}|}{|\hat{A}+\hat{B}|}=\tan\frac{\theta}{2}$$

$$|\hat{A}-\hat{B}|=|\hat{A}+\hat{B}|\tan\frac{\theta}{2}$$

119. Match List I with List II.

List-I	List-II
(A) C−A−B=0	**i)** 
(B) A−C−B=0	**ii)** 
(C) B−A−C=0	**iii)** 
(D) A+B=−C	**iv)** 

Choose the correct answer from the options given below.

(a) (A) → (iv), (B) → (i), (C) → (iii), (D) → (ii)

(b) (A) → (iv), (B) → (iii), (C) → (i), (D) → (ii)

(c) (A) → (iii), (B) → (ii), (C) → (iv), (D) → (i)

(d) (A) → (i), (B) → (iv), (C) → (ii), (D) → (iii)

JEE Main-25.07.2021, Shift-I

Ans. (b) : Applying triangle law of vectors to the diagram.

(i) $\vec{B}=\vec{A}+\vec{C}$

$\therefore\ \vec{B}-\vec{A}-\vec{C}=0$

This matches with (C).

(ii) $-\vec{C}=\vec{A}+\vec{B}$

This matches with (D).

(iii) $\vec{C}+\vec{B}=\vec{A}$

$\therefore\ \vec{A}-\vec{C}=\vec{B}$

This matches with (B).

(iv) $\vec{A}+\vec{B}=\vec{C}$

$\therefore\ \vec{C}-\vec{A}-\vec{B}=0$

120. Two vectors P and Q have equal magnitudes. If the magnitude of P+Q is n times the magnitude of P−Q, then angle between P and Q is

(a) $\sin^{-1}\left(\frac{n-1}{n+1}\right)$ (b) $\cos^{-1}\left(\frac{n-1}{n+1}\right)$

(c) $\sin^{-1}\left(\frac{n^2-1}{n^2+1}\right)$ (d) $\cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

JEE Main-25.07.2021, Shift-II
JEE Main-20.07.2021, Shift-II
JEE Main-10.01.2019, Shift-II

Ans. (d) : Given that,

$$P = Q \qquad .....(i)$$

Let the magnitude of (P + Q) = R

$$R = |P+Q| = \sqrt{P^2+Q^2+2PQ\cos\theta}$$

$$R=\sqrt{P^2+P^2+2P^2\cos\theta} \qquad \text{[from (i)]}$$

The magnitude of (P – Q) = R'

$$R' = |P-Q| = \sqrt{P^2+Q^2-2PQ\cos\theta}$$

$$R' = |P-Q| = \sqrt{P^2+P^2-2P^2\cos\theta} \qquad \text{[from (i)]}$$

Given that

R = nR'

$$\sqrt{2P^2+2P^2\cos\theta}=n\sqrt{2P^2-2P^2\cos\theta}$$

squaring both side

$2p^2 + 2p^2\cos\theta = n^2(2p^2 - 2p^2\cos\theta)$

@apna_pdf

$2p^2(1+\cos\theta) = n^2 2p^2(1-\cos\theta)$

$1 + \cos\theta = n^2(1 - \cos\theta)$

$1 + \cos\theta = n^2 - n^2\cos\theta$

$\cos\theta + n^2\cos\theta = n^2 - 1$

$\cos\theta(1 + n^2) = n^2 - 1$

$$\cos\theta = \frac{n^2-1}{n^2+1}$$

$$\theta = \cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$$

121. If A and B are two vectors satisfying the relation $\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$. Then, the value of $|\vec{A}-\vec{B}|$ will be

(a) $\sqrt{A^2+B^2}$ (b) $\sqrt{A^2+B^2+\sqrt{2}AB}$

(c) $\sqrt{A^2+B^2+2AB}$ (d) $\sqrt{A^2+B^2-\sqrt{2}AB}$

JEE Main-20.07.2021, Shift-I

Ans. (d) : Given that,

$$\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$$

AB cosθ = AB sinθ

tanθ = 1

$\theta = \tan^{-1}(1)$

θ = 45°

The value of $|\vec{A}-\vec{B}|$ is

$$|\vec{A}-\vec{B}| = \sqrt{A^2+B^2-2AB\cos 45^\circ}$$

$$|\vec{A}-\vec{B}| = \sqrt{A^2+B^2-\sqrt{2}AB}$$

122. If P ×Q =Q ×P, the angle between P and Q is θ (0°< θ <360°). The value of θ will be ……………°.

JEE Main-25.02.2021, Shift-II

Ans. (180) :

If $\vec{P}\times\vec{Q} = \vec{Q}\times\vec{P}$

$\vec{P}\times\vec{Q} = -\vec{P}\times\vec{Q}$

$2(\vec{P}\times\vec{Q}) = 0$

If $\vec{P} = 0$ or $\vec{Q} = 0$

The angle between $\vec{P}$ & $\vec{Q}$ is 180º (0º<θ < 360º)

So, θ = 180º

123. Let $|\vec{A}_1| = 3, |\vec{A}_2| = 5$ and $|\vec{A}_1+\vec{A}_2| = 5$. The value of $(2\vec{A}_1+3\vec{A}_2).(3\vec{A}_1-2\vec{A}_2)$ is

(a) −106.5 (b) −112.5

(c) −99.5 (d) −118.5

JEE Main-08.04.2019, Shift-II

Ans. (d) : Given that

$|\vec{A}_1| = 3, |\vec{A}_2| = 5, |\vec{A}_1+\vec{A}_2| = 5$

$$|\vec{A}_1+\vec{A}_2| = \sqrt{|\vec{A}_1|^2+|\vec{A}_2|^2+2|\vec{A}_1||\vec{A}_2|\cos\theta}$$

$$5 = \sqrt{(3)^2+(5)^2+2\times3\times5\cos\theta}$$

$$5 = \sqrt{9+25+2\times3\times5\cos\theta}$$

Squaring both side

25 = 9+25+2× 3 × 5 cosθ

$$\cos\theta = \frac{-9}{2\times3\times5}$$

$$\cos\theta = \frac{-3}{10}$$

$(2\vec{A}_1+3\vec{A}_2).(3\vec{A}_1-2\vec{A}_2)$

$= 6|\vec{A}_1|^2 + 9\vec{A}_1\cdot\vec{A}_2 - 4\vec{A}_1\cdot\vec{A}_2 - 6|\vec{A}_2|^2$

$= 6(3)^2 + 9\vec{A}_1.\vec{A}_2 - 4\vec{A}_1.\vec{A}_2 - 6\times25$

$= 54 + 5\vec{A}_1.\vec{A}_2 - 6\times25$

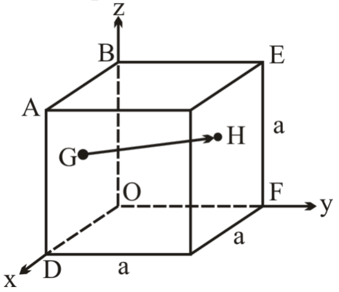
$= 54 + 5|\vec{A}_1||\vec{A}_2|\cos\theta - 150$

$$= 54 + 5\times3\times5\left(\frac{-3}{10}\right) - 150$$

$$= 54 - 150 - \frac{45}{2}$$

= – 118.5

124. In the cube of side 'a' shown in the figure, the vector from the central point of the face ABOD to the central point of the face BEFO will be

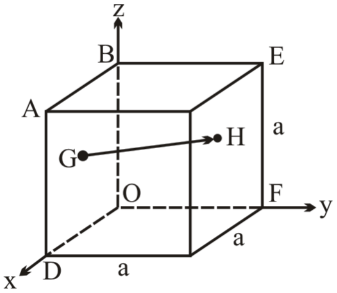


(a) $\frac{1}{2}a(\hat{i}-\hat{k})$ (b) $\frac{1}{2}a(\hat{j}-\hat{i})$

(c) $\frac{1}{2}a(\hat{j}-\hat{k})$ (d) $\frac{1}{2}a(\hat{k}-\hat{i})$

JEE Main-10.01.2019, Shift-I

Ans. (b) :



Position vector of G is, $G\left(\frac{a}{2}, 0, \frac{a}{2}\right)$

$$\overline{OG} = \frac{a}{2}\hat{i} + \frac{a}{2}\hat{k}$$

@apna_pdf

Position vector of H is, $H\left(0,\frac{a}{2},\frac{a}{2}\right)$

$\overrightarrow{OH}=\frac{a}{2}\hat{j}+\frac{a}{2}\hat{k}$

$\overrightarrow{GH}=\overrightarrow{OH}-\overrightarrow{OG}$

$\overrightarrow{GH}=\left(\frac{a}{2}\hat{j}+\frac{a}{2}\hat{k}\right)-\left(\frac{a}{2}\hat{i}+\frac{a}{2}\hat{k}\right)$

$\overrightarrow{GH}=\frac{a}{2}\left(\hat{j}-\hat{i}\right)$

125. If $\vec{A}\times\vec{B}=\vec{B}\times\vec{A}$, then the angle between A and B is

(a) π (b) $\pi/3$

(c) $\pi/2$ (d) $\pi/4$

AIEEE-2004

Ans. (a) :

$\vec{A}\times\vec{B}=\vec{B}\times\vec{A}$

$\vec{A}\times\vec{B}=-(\vec{A}\times\vec{B})$

$AB\sin\theta=-AB\sin\theta$

$2AB\sin\theta=0$

$\sin\theta=0$

$\theta=0,\ \pi,\ 2\pi$

126. $\vec{A}=3\hat{i}+4\hat{j}+2\hat{k},\vec{B}=6\hat{i}-\hat{j}+3\hat{k}$ Find a vector parallel to $\vec{A}$ whose magnitude equal to that of $\vec{B}$

(a) $\sqrt{\frac{46}{29}}\left(3\hat{i}+4\hat{j}+2\hat{k}\right)$ (b) $\sqrt{\frac{46}{29}}\left(6\hat{i}-\hat{j}+3\hat{k}\right)$

(c) $\sqrt{\frac{29}{46}}\left(3\hat{i}+4\hat{j}+2\hat{k}\right)$ (d) $\sqrt{\frac{29}{46}}\left(6\hat{i}-\hat{j}+3\hat{k}\right)$

Assam CEE-2020

Ans. (a) : Givne that,

$\vec{A}=3\hat{i}+4\hat{j}+2\hat{k}$

$\vec{B}=6\hat{i}-\hat{j}+3\hat{k}$

Let X be the vector parallel to $\vec{A}$ whose magnitude is equal to that of $\vec{B}$

$$\vec{X}=\frac{\vec{A}|\vec{B}|}{|\vec{A}|}$$

$$=\frac{3\hat{i}+4\hat{j}+2\hat{k}}{\sqrt{9+16+4}}\sqrt{36+1+9}$$

$$\vec{X}=\frac{\sqrt{46}}{\sqrt{29}}\left(3\hat{i}+4\hat{j}+2\hat{k}\right)$$

127. A body constrianed to move along the z-axis of a co-ordinate system is subject to a constant force $\vec{F}$ given by $\vec{F}=\left(-\hat{i}+2\hat{j}+3\hat{k}\right)$N. The work done by this force in moving the body a distance 4m along the z-axis is.

(a) $\left(-4\hat{i}+8\hat{j}+12\hat{k}\right)$N (b) $\left(-4\hat{i}+8\hat{j}\right)$N

(c) 12 N (d) $12\hat{k}$N

Assam CEE-2021

Ans. (c) : Given

$\vec{F}=\left(-\hat{i}+2\hat{j}+3\hat{k}\right)$

$\vec{d}=\left(0\hat{i}+0\hat{j}+4\hat{k}\right)$

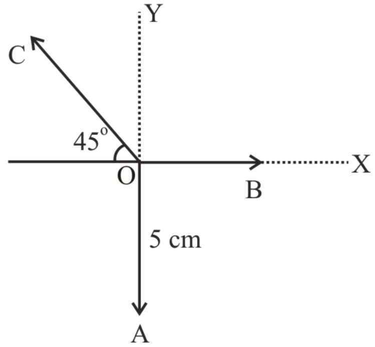
Work done is given by-

$W=\vec{F}.\vec{d}$

$=\left(-\hat{i}+2\hat{j}+3\hat{k}\right)\left(0\hat{i}+0\hat{j}+4\hat{k}\right)$

$=0+0+12=12$N

128. The sum of three vectors in the figure below is zero. The magnitude of $\overline{OC}$ and $\overline{OB}$ is



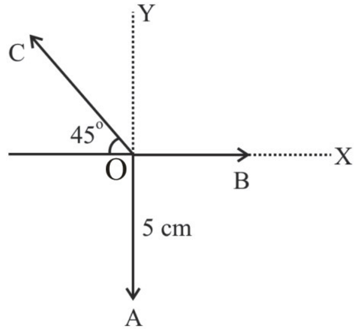
(a) 5 m, $5\sqrt{2}$ m (b) 5 m, 5 m

(c) $5\sqrt{2}$ m, 5m (d) $5\sqrt{2}$ m, $5\sqrt{2}$ m

Assam CEE-2018

Ans. (c) : Given, the sum of three vectors in given figure is zero

i.e. $0\hat{i}+0\hat{j}+0\hat{k}=0$ ......(i)



Now,

$\overrightarrow{OA}=5(-\hat{j})=-5\hat{j}$

$\overrightarrow{OB}=OB\ (\hat{i})$

$\overrightarrow{OC}=OC\cos45°(-\hat{i})+OC\sin45°\hat{j}$

$=-\frac{OC}{\sqrt{2}}\hat{i}+\frac{OC}{\sqrt{2}}\hat{j}$

$\vec{R}=\left(OB-\frac{OC}{\sqrt{2}}\right)\hat{i}+\left(-5+\frac{OC}{\sqrt{2}}\right)\hat{j}$ .....(ii)

@apna_pdf

Comparing equation (i) and (ii), we get

$$0\hat{i}+0\hat{j}=\left(OB-\frac{OC}{\sqrt{2}}\right)\hat{i}+\left(-5+\frac{OC}{\sqrt{2}}\right)\hat{j}$$

$$OB-\frac{OC}{\sqrt{2}}=0\Rightarrow OB=\frac{OC}{\sqrt{2}}$$

$$\frac{OC}{\sqrt{2}}-5=0$$

$$OC=5\sqrt{2}\,m$$

Then, $OB=\dfrac{5\sqrt{2}}{\sqrt{2}}=5m$

129. The unit vector perpendicular to the plane of $\vec{A}=\hat{i}-3\hat{j}-\hat{k}$ and $\vec{B}=2\hat{i}+\hat{j}-\hat{k}$ is

(a) $\frac{4}{\sqrt{66}}\hat{i}-\frac{1}{\sqrt{66}}\hat{j}+\frac{7}{\sqrt{66}}\hat{k}$

(b) $\frac{2}{\sqrt{66}}\hat{i}-\frac{1}{\sqrt{66}}\hat{j}+\frac{8}{\sqrt{66}}\hat{k}$

(c) $\frac{4}{\sqrt{66}}\hat{i}+\frac{1}{\sqrt{66}}\hat{j}+\frac{7}{\sqrt{66}}\hat{k}$

(d) $\frac{2}{\sqrt{66}}\hat{i}+\frac{1}{\sqrt{66}}\hat{j}+\frac{8}{\sqrt{66}}\hat{k}$

Assam CEE-2016

Ans. (a) : Given,

$$\vec{A}=\left(\hat{i}-3\hat{j}-\hat{k}\right)\text{ and }\vec{B}=\left(2\hat{i}+\hat{j}-\hat{k}\right)$$

$$\vec{A}\times\vec{B}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & -3 & -1\\ 2 & 1 & -1\end{vmatrix}$$

$$=\hat{i}\left(3-(-1)\right)-\hat{j}\left(-1-(-2)\right)+\hat{k}\left(1-(-6)\right)$$

$$=4\hat{i}-\hat{j}+7\hat{k}$$

Now, $\left|\vec{A}\times\vec{B}\right|=\sqrt{4^2+(-1)^2+7^2}$

$$=\sqrt{16+1+49}=\sqrt{66}$$

So, Unit vector perpendicular to the planes $\vec{A}$ and $\vec{B}$ is $\dfrac{\vec{A}\times\vec{B}}{\left|\vec{A}\times\vec{B}\right|}$

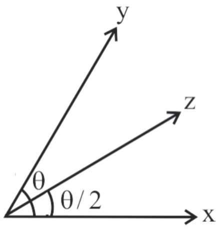
$$=\frac{4\hat{i}}{\sqrt{66}}-\frac{\hat{j}}{\sqrt{66}}+\frac{7\hat{k}}{\sqrt{66}}$$

130. The angle between two vectors x and y is θ. If the resultant vector z makes an angle θ/2 with x, then which of the following is true?

(a) x = 2y
(b) x = y
(c) x = 2y + 1
(d) $x=\frac{y}{2}$

Assam CEE-2016

Ans. (b) :



The angle β which the resultant = makes with x is given by

$$\tan\beta=\frac{y\sin\theta}{x+y\cos\theta}$$

$$\tan\left(\frac{\theta}{2}\right)=\frac{y\sin\theta}{x+y\cos\theta}\quad\left[\because\beta=\frac{\theta}{2}\right]$$

$$\frac{\sin\theta/2}{\cos\theta/2}=\frac{y\times\left(2\sin\theta/2.\cos\theta/2\right)}{x+y\cos\theta}$$

$$x+y\cos\theta=2y.\cos^2\theta/2$$

$$x+y\left(2\cos^2\frac{\theta}{2}-1\right)=y.2\cos^2\frac{\theta}{2}$$

$$x-y=0$$

$$x=y$$

131. The resultant of three vectors $\vec{A}(2\hat{i}-\hat{j}+3\hat{k})$, $\vec{B}(3\hat{i}-2\hat{j}-2\hat{k})$ and $\vec{C}$ is a unit vector along $\vec{z}$ direction is given by

(a) $\vec{C}=3\hat{j}+5\hat{k}$
(b) $\vec{C}=3\hat{i}+2\hat{k}$
(c) $\vec{C}=5\hat{i}+\hat{k}$
(d) $\vec{C}=-5\hat{i}+3\hat{j}$

Tripura-2020

Ans. (d) : $\vec{A}=\left(2\hat{i}-\hat{j}+3\hat{k}\right)$

$$\vec{B}=\left(3\hat{i}-2\hat{j}-2\hat{k}\right)$$

Let $\vec{C}=\left(x\hat{i}+y\hat{j}+z\hat{k}\right)$

Now $\vec{A}+\vec{B}+\vec{C}=1$ unit along z-direction

$$\left(2\hat{i}-\hat{j}+3\hat{k}\right)+\left(3\hat{i}-2\hat{j}-2\hat{k}\right)+\left(x\hat{i}+y\hat{j}+z\hat{k}\right)=1\hat{k}$$

$$(2+3+x)\hat{i}+(-1-2+y)\hat{j}+(3-2+z)\hat{k}=1\hat{k}$$

$$(5+x)\hat{i}+(-3+y)\hat{j}+(1+z)\hat{k}=1\hat{k}$$

By comparing both side

$5+x=0\Rightarrow x=-5$
$y-3=0\Rightarrow y=3$
$1+z=1\Rightarrow z=0$

Now $\vec{C}=\left(x\hat{i}+y\hat{j}+z\hat{k}\right)$

$$=\left(-5\hat{i}+3\hat{j}+0\hat{k}\right)$$

$$\boxed{\vec{C}=-5\hat{i}+3\hat{j}}$$

132. If $\vec{A}$ and $\vec{B}$ are two vectors, then the value of $(\vec{A}+\vec{B})\times(\vec{A}-\vec{B})$ is

(a) $2(\vec{B}\times\vec{A})$
(b) $-2(\vec{B}\times\vec{A})$
(c) $\vec{B}\times\vec{A}$
(d) $\vec{A}\times\vec{B}$

HP CET-2018

@apna_pdf

Ans. (a) : If $\vec{A}$ and $\vec{B}$ are two vector
Then,

$$(\vec{A}+\vec{B})\times(\vec{A}-\vec{B})$$
$$=\vec{A}\times(\vec{A}-\vec{B})+\vec{B}\times(\vec{A}-\vec{B})$$
$$=\vec{A}\times\vec{A}-\vec{A}\times\vec{B}+\vec{B}\times\vec{A}-\vec{B}\times\vec{B} \qquad \begin{bmatrix}\because \vec{A}\times\vec{A}=0\\ \vec{B}\times\vec{B}=0\end{bmatrix}$$
$$=0-\vec{A}\times\vec{B}+\vec{B}\times\vec{A}-0$$
$$=\vec{B}\times\vec{A}+\vec{B}\times\vec{A} \qquad (\because -\vec{A}\times\vec{B}=\vec{B}\times\vec{A})$$
$$=2(\vec{B}\times\vec{A})$$

133. Two position vectors are given by $\vec{r}_1=(1,1,1)$ and $\vec{r}_2=(1,-1,1)$. The unit vector in the direction of $\vec{r}_1\times\vec{r}_2$

(a) $\frac{\hat{i}}{\sqrt{2}}-\frac{\hat{k}}{\sqrt{2}}$ (b) $-\frac{\hat{i}}{\sqrt{2}}-\frac{\hat{k}}{\sqrt{2}}$

(c) $\frac{\hat{i}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}$ (d) $-\frac{\hat{i}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}$

AP EAMCET-06.07.2022, Shift-I

Ans. (a) : Given,

$$\vec{r}_1=\hat{i}+\hat{j}+\hat{k}$$
$$\vec{r}_2=\hat{i}-\hat{j}+\hat{k}$$
$$\vec{r}_1\times\vec{r}_2=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 1 & 1\\ 1 & -1 & 1\end{vmatrix}$$
$$=\hat{i}(1-(-1))-\hat{j}(1-1)+\hat{k}(-1-1)$$
$$=2\hat{i}-0\hat{j}-2\hat{k}$$
$$=2\hat{i}-2\hat{k}$$
$$|\vec{r}_1\times\vec{r}_2|=\sqrt{2^2+(-2)^2}$$
$$=2\sqrt{2}$$

The unit vector in direction of $\vec{r}_1\times\vec{r}_2$ is $\frac{\vec{r}_1\times\vec{r}_2}{|\vec{r}\times\vec{r}_2|}$

$$=\frac{2\hat{i}}{2\sqrt{2}}-\frac{2\hat{k}}{2\sqrt{2}}$$
$$=\frac{\hat{i}}{\sqrt{2}}-\frac{\hat{k}}{\sqrt{2}}$$

134. A uniform force of $(4\hat{i}+3\hat{j})$ newton acts on a body mass 5 kg. The body is displaced from $(4\hat{i}-3\hat{j}-2\hat{k})$ m to $(5\hat{i}-4\hat{j}+2\hat{k})$ m. Then, the work done by the force on the body in joule is

(a) 1 (b) 5

(c) 7 (d) 11

AP EAMCET-11.07.2022, Shift-II

Ans. (a) : Given data

$$\vec{F}=(4\hat{i}+3\hat{j})\text{N}$$
$$\vec{r}_1=(4\hat{i}-3\hat{j}-2\hat{k})\text{m}$$
$$\vec{r}_2=(5\hat{i}-4\hat{j}+2\hat{k})\text{m}$$

$\therefore$ Displacement, $\vec{d}=\vec{r}_2-\vec{r}_1$

$$\vec{d}=(5\hat{i}-4\hat{j}+2\hat{k})-(4\hat{i}-3\hat{j}-2\hat{k})$$
$$\vec{d}=\hat{i}-\hat{j}+4\hat{k}$$

$\therefore$ Work done $=\vec{F}.\vec{d}=(4\hat{i}+3\hat{j}).(\hat{i}-\hat{j}+4\hat{k})$

$$\vec{F}.\vec{d}=4-3$$
$$\vec{F}.\vec{d}=1\text{ Joule}$$

135. The dot product of $\vec{A}=(\hat{i}+\hat{j}+\hat{k})$ and the unit vector parallel to $(\hat{i}-\hat{j}+\hat{k})$ is

(a) $\frac{1}{\sqrt{3}}$ (b) $\frac{2}{\sqrt{3}}$

(c) $\sqrt{3}$ (d) 3

AP EAMCET-11.07.2022, Shift-II

Ans. (a) : $\vec{A}=\hat{i}+\hat{j}+\hat{k}$ and unit vector parallel to $(\hat{i}-\hat{j}+\hat{k})$ is $=\frac{\vec{A}\cdot\vec{B}}{|\vec{B}|}=\frac{(\hat{i}+\hat{j}+\hat{k})\cdot(\hat{i}-\hat{j}+\hat{k})}{\sqrt{1^2+(-1)^2+(1)^2}}$

$$=\frac{1}{\sqrt{3}}$$

136. The component of a vector $\vec{P}=3\hat{i}+8\hat{j}$ along the direction $(\hat{i}+2\hat{j})$ is

(a) $\frac{8}{\sqrt{5}}$ (b) $\frac{19}{\sqrt{5}}$

(c) $\frac{11}{\sqrt{5}}$ (d) $\sqrt{10}$

AP EAMCET-05.07.2022, Shift-I

Ans. (b) : $\vec{P}=3\hat{i}+8\hat{j}$ $\quad\vec{Q}=\hat{i}+2\hat{j}$

$\vec{P}$ component along $\vec{Q}$ direction $=\vec{P}\hat{Q}$

$$=\frac{\vec{P}.\vec{Q}}{|\vec{Q}|}=\frac{(3\hat{i}+8\hat{j})(\hat{i}+2\hat{j})}{\sqrt{1+2^2}}=\frac{3+16}{\sqrt{5}}=\frac{19}{\sqrt{5}}$$

137. Which of the following is not true about vectors $\vec{A},\vec{B}$ and $\vec{C}$?

(a) $(\vec{A}\cdot\vec{A})(\vec{B}\cdot\vec{C})$ is a scalar value.

(b) $(\vec{A}\times\vec{B})\cdot(\vec{B}\times\vec{C})$ is a scalar value.

(c) $(\vec{A}\times\vec{C})\times(\vec{B}\times\vec{C})$ is a scalar value.

(d) $\vec{A}\times(\vec{B}\times\vec{C})$ is a vector value.

AP EAMCET-04.07.2022, Shift-II

@apna_pdf

Ans. (c) : For $\vec{A},\vec{B}$ and $\vec{C}$

i.e. $\left(\vec{A}\times\vec{C}\right)\times\left(\vec{B}\times\vec{C}\right)$ is a vector value.

The cross product is always vector quantity.

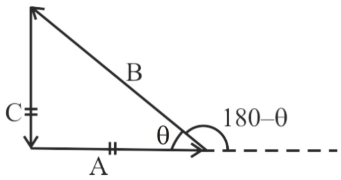
138. If A + B = C and that C is perpendicular to A. What is the angle between A and B, if |A| = |C|?

(a) $\frac{\pi}{4}$rad (b) $\frac{\pi}{2}$rad

(c) $\frac{3\pi}{4}$rad (d) π rad

JIPMER-2016

Ans. (c) : Given, $\left|\vec{A}\right|=\left|\vec{C}\right|$



From figure,

$$\tan\theta=\frac{C}{A}$$

$$\cot\theta=\frac{A}{C}=\frac{C}{C}=1 \qquad (\therefore A=C)$$

$$\theta=45°$$

So the angle between $\vec{A}$ and $\vec{B}$

$$180-\theta=180-45$$
$$=135°$$
$$=135\times\frac{\pi}{180}$$
$$=3\pi/4 \text{ radian}$$

139. The angle between two linear trans-membranes domains is defined by following vectors $\mathbf{a}=\hat{\mathbf{i}}+\hat{\mathbf{j}}-\hat{\mathbf{k}}$ and $\hat{\mathbf{i}}-\hat{\mathbf{j}}+\hat{\mathbf{k}}$

(a) $\cos^{-1}\left(\frac{1}{3}\right)$ (b) $\cos^{-1}\left(\frac{-1}{3}\right)$

(c) $\sin^{-1}\left(\frac{-1}{3}\right)$ (d) $\sin^{-1}\left(\frac{1}{3}\right)$

JIPMEER-2015

Ans. (b) : Given vectors,

$$\vec{a}=\hat{i}+\hat{j}-\hat{k}$$
$$\vec{b}=\hat{i}-\hat{j}+\hat{k}$$

angle between two linear trans membrane domains

$$\cos\theta=\frac{\vec{a}.\vec{b}}{|\vec{a}||\vec{b}|}$$

$$=\frac{\left(\hat{i}+\hat{j}-\hat{k}\right).\left(\hat{i}-\hat{j}+\hat{k}\right)}{\sqrt{(1)^2+(1)^2+(-1)^2}\sqrt{(1)^2+(-1)^2+(1)^2}}$$

$$=\frac{1-1-1}{\sqrt{3}\sqrt{3}}$$

$$\cos\theta=\frac{-1}{3}$$

$$\boxed{\theta=\cos^{-1}\left(-\frac{1}{3}\right)}$$

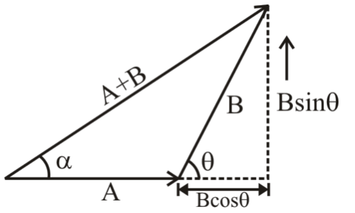
140. $\vec{A}$ and $\vec{B}$ are two vectors of equal magnitudes and θ is the angle between them. The angle between $\vec{A}$ or $\vec{B}$ with their resultant is

(a) $\frac{\theta}{4}$ (b) $\frac{\theta}{2}$

(c) 2 θ (d) Zero

AP EAMCET -2010

Ans. (b) : Given, $\left|\vec{A}\right|=\left|\vec{B}\right|$



$$\therefore \quad \tan\alpha=\frac{B\sin\theta}{A+B\cos\theta} \qquad (\because|A|=|B|)$$

$$\tan\alpha=\frac{\sin\theta}{1+\cos\theta}$$

$$\tan\alpha=\frac{2\sin\frac{\theta}{2}.\cos\frac{\theta}{2}}{1+2\cos^2\frac{\theta}{2}-1}$$

$$\tan\alpha=\frac{2\sin\frac{\theta}{2}.\cos\frac{\theta}{2}}{2\cos^2\frac{\theta}{2}}$$

$$\tan\alpha=\tan\frac{\theta}{2}$$

$$\alpha=\frac{\theta}{2}$$

141. Find the angle between the vectors $\vec{\mathbf{A}}=2\hat{\mathbf{i}}+4\hat{\mathbf{j}}+4\hat{\mathbf{k}}$ and $\vec{\mathbf{B}}=4\hat{\mathbf{i}}+2\hat{\mathbf{j}}-4\hat{\mathbf{k}}$.

(a) 0° (b) 45°

(c) 60° (d) 90°

AP EAMCET-24.08.2021, Shift-I

Ans. (d) : Given,

$$\vec{A}=2\hat{i}+4\hat{j}+4\hat{k}$$

and $$\vec{B}=4\hat{i}+2\hat{j}-4\hat{k}$$

Since $$\vec{A}.\vec{B}=\left(2\hat{i}+4\hat{j}+4\hat{k}\right)\cdot\left(4\hat{i}+2\hat{j}-4\hat{k}\right)$$

$$=(2\times4)+(4\times2)-(4\times4)$$

$$=8+8-16=0$$

@apna_pdf

$$\cos\theta = \frac{\vec{A}\cdot\vec{B}}{|\vec{A}||\vec{B}|}$$

$$\cos\theta = \frac{8+8-16}{\sqrt{4+16+16}\sqrt{16+4+16}}$$

$\cos\theta = 0$

$\cos\theta = \cos 90^\circ$

$\theta = 90^\circ$

Hence, vectors $\vec{A}$ and $\vec{B}$ are perpendicular to each other.

142. The resultant of the two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to the vector $\vec{A}$ and its magnitude is equal to half of the magnitude of vector $\vec{B}$. Then the angle between $\vec{A}$ and $\vec{B}$ is—.

(a) 30° (b) 45°

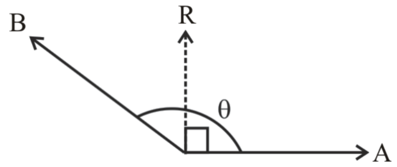
(c) 150° (d) 120°

AP EAMCET-06.09.2021, Shift-I

Ans. (c) : Given that R = B/2

Resultant of two forces

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta} \quad \text{... (i)}$$



A and R are perpendicular to each other

$\therefore \tan 90^\circ = \dfrac{B\sin\theta}{A + B\cos\theta} \Rightarrow A + B\cos\theta = 0$

$\therefore \cos\theta = -A/B$

put the value of cos θ in equation (i).

$$\frac{B}{2} = \sqrt{A^2 + B^2 + 2AB\left(\frac{-A}{B}\right)}$$

$$\frac{B^2}{4} = A^2 + B^2 - 2A^2$$

$$\frac{B^2}{4} = B^2 - A^2$$

$$\frac{3B^2}{4} = A^2 \Rightarrow A = \frac{\sqrt{3}B}{2}$$

$$\cos\theta = -A/B = -\frac{\sqrt{3}}{2}$$

$\therefore \theta = 150^\circ$

The angle between A and B is 150°.

143. When a force $\vec{F}$ given by $\vec{F} = 6\hat{i} - 18\hat{j} + 10\hat{k}$ acts on a body, it imparts an acceleration of 8 m.s^{-2}. Then find the mass of the body ——

(a) $\dfrac{\sqrt{115}}{4}$ kg (b) $10\sqrt{2}$ kg

(c) $\dfrac{\sqrt{115}}{2}$ kg (d) $\dfrac{115}{2}$ kg

AP EAMCET-24.08.2021, Shift-I

Ans. (a) : Magnitude of the force is given as –

$$F = \sqrt{6^2 + (-18)^2 + 10^2}\ \text{N}$$

$$F = \sqrt{36 + 324 + 100}\ \text{N}$$

$$F = \sqrt{460}\ \text{N} \Rightarrow F = 2\sqrt{115}\ \text{N}$$

Force = Mass × Acceleration

$$\text{Mass} = \frac{2\sqrt{115}}{8} \Rightarrow \text{Mass} = \frac{\sqrt{115}}{4}\,\text{kg}$$

144. For the resultant of two vectors $\vec{A}$ and $\vec{B}$ to maximum. The angle between them should be ____.

(a) 180° (b) 0°

(c) 90° (d) 60°

AP EAMCET-23.08.2021, Shift-II

Ans. (b) : For maximum Resultant

$$F_R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

For maximum

$\cos\theta = 1$

$\theta = 0^\circ$

Then resultant force

$$F_R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2}$$

$$\boxed{F_R = F_1 + F_2}$$

For minimum $\cos\theta = -1$

$\theta = 180^\circ$

Then resultant force

$$F_R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2} \Rightarrow F_R = F_1 - F_2$$

145. The vectors $\vec{A} = (\hat{i} + \hat{j} - 2\hat{k}), \vec{B} = (2\hat{i} + 2\hat{j} - \hat{k})$ and $\vec{C} = (-\hat{i} + \alpha\hat{j} + \hat{k})$ are coplanar when the constant α is equal to

(a) 1/3 (b) 1

(c) 3 (d) none of these

AMU-2008

Ans. (d) : Given,

$$\vec{A} = \hat{i} + \hat{j} - 2\hat{k}$$

$$\vec{B} = 2\hat{i} + 2\hat{j} - \hat{k}$$

And $\vec{C} = -\hat{i} + \alpha\hat{j} + \hat{k}$

Here, three vector $\vec{A}, \vec{B}, \vec{C}$ are coplanar if

$$\left[\vec{A}\,\vec{B}\,\vec{C}\right] = 0$$

$$\therefore \begin{vmatrix} 1 & 1 & -2 \\ 2 & 2 & -1 \\ -1 & \alpha & 1 \end{vmatrix} = 0$$

$1(2 + \alpha) - 1(2 - 1) - 2(2\alpha + 2) = 0$

$2 + \alpha - 1 - 4\alpha - 4 = 0$

$-3\alpha - 3 = 0$

Or $\alpha = -\dfrac{1}{3}$

@apna_pdf

146. If $\vec{A} = \hat{i} - \hat{j}$ and $\vec{B} = 3\hat{i} + 4\hat{j}$, the vector having same magnitude as $\vec{B}$ but parallel to vector $\vec{A}$ can be written as

(a) $5(\hat{i} - \hat{j})$ (b) $(5/\sqrt{2})(\hat{i} - \hat{j})$

(c) $\sqrt{2}(4\hat{i} - 3\hat{j})$ (d) $\sqrt{3}(\hat{i} - \hat{j})$

AMU-2019

Ans. (b) : Given,

$$\vec{A} = \hat{i} - \hat{j}$$

$$\vec{B} = 3\hat{i} + 4\hat{j}$$

$$(\hat{A}) = \frac{\vec{A}}{|\vec{A}|} = \frac{(\hat{i} - \hat{j})}{\sqrt{1+1}} = \frac{1}{\sqrt{2}}(\hat{i} - \hat{j})$$

Magnitude of $(|\vec{B}|) = \sqrt{(3)^2 + (4)^2} = \sqrt{9+16} = 5$

$\because$ Vector having magnitude of $\vec{B}$ and parallel to $\vec{A}$.

$$\therefore \quad |\vec{B}|.\hat{A} = 5.\frac{1}{\sqrt{2}}(\hat{i} - \hat{j})$$

$$|\vec{B}|.\hat{A} = \frac{5}{\sqrt{2}}(\hat{i} - \hat{j})$$

147. Find the component of vector $\vec{A} = 2\hat{i} + 3\hat{j}$ along the direction $(\hat{i} - \hat{j})$.

(a) $-\frac{1}{2}(\hat{i} - \hat{j})$ (b) $-\frac{1}{2}(\hat{i} + \hat{j})$

(c) $\frac{1}{2}(\hat{i} - \hat{j})$ (d) $\frac{1}{2}(\hat{i} + \hat{j})$

AMU-2013

Ans. (a) : $\vec{A} = 2\hat{i} + 3\hat{j}$

$$\vec{B} = \hat{i} - \hat{j}$$

Unit vector $\hat{B}$

$$\hat{B} = \frac{\vec{B}}{|\vec{B}|} = \frac{\hat{i} - \hat{j}}{\sqrt{(1)^2 - (-1)^2}}$$

$$\hat{B} = \frac{\hat{i} - \hat{j}}{\sqrt{2}}$$

Component of $\vec{A}$ along $\vec{B} = \frac{\vec{A} \cdot \vec{B}}{|\vec{B}|} = \vec{A} \cdot \hat{B}$

To get vector form $= [\vec{A}\hat{B}]\hat{B}$

$$= \left[(2\hat{i} + 3\hat{j}) \cdot \frac{1}{\sqrt{2}}(\hat{i} - \hat{j})\right]\frac{1}{\sqrt{2}}(\hat{i} - \hat{j})$$

$$= \left[-\frac{1}{\sqrt{2}}\right]\frac{1}{\sqrt{2}}(\hat{i} - \hat{j})$$

$$= -\frac{1}{2}(\hat{i} - \hat{j})$$

148. The angle between the vectors : $\vec{a} = 3\vec{i} - 4\vec{j}$ and $\vec{b} = -2\vec{i} + 3\vec{k}$ is

(a) $\cos^{-1}\left(-\frac{1}{3}\right)$ (b) $\cos^{-1}\left(-\frac{1}{4}\right)$

(c) $\cos^{-1}\left(-\frac{1}{2}\right)$ (d) $\cos^{-1}\left(-\frac{1}{6}\right)$

AMU-2012

Ans. (a) : Given

$\vec{a} = 3\vec{i} - 4\vec{j}$ and $\vec{b} = -2\vec{i} + 3\vec{k}$

We know

$$\cos\theta = \frac{\vec{a}.\vec{b}}{|\vec{a}| \cdot |\vec{b}|}$$

$$\cos\theta = \frac{(3\vec{i} - 4\vec{j}).(-2\vec{i} + 3\vec{k})}{\sqrt{(3)^2 + (-4)^2}\sqrt{(-2)^2 + (3)^2}}$$

$$\cos\theta = \frac{-6}{5\sqrt{13}} \qquad [\sqrt{13} = 3.606]$$

$$\cos\theta = \frac{-6}{18} \Rightarrow \quad \cos\theta = \frac{-1}{3}$$

$$\theta = \cos^{-1}\left(-\frac{1}{3}\right)$$

149. Vector $\vec{A}$ has a magnitude of 5 units, lies in the xy-plane and points in a direction 120° from the direction of increasing x. Vector $\vec{B}$ has a magnitude of 9 units and points along the z-axis. The magnitude of cross product $\vec{A} \times \vec{B}$ is

(a) 30 (b) 35

(c) 40 (d) 45

AMU-2012

Ans. (d) : We know that,

A×B = |A| |B| sinθ

Vector B makes angle of 90° with A

A×B = 5×9 sin 90°

A×B = 45

150. If $\vec{A} = \hat{i} + \hat{j}$, and $\vec{B} = \hat{i} + \hat{k}$, then $\vec{A} \times \vec{B}$ is

(a) $\hat{i} + \hat{j} + \hat{k}$ (b) $\hat{i} - \hat{j} + \hat{k}$

(c) $\hat{i} + \hat{j} - \hat{k}$ (d) $\hat{i} - \hat{j} - \hat{k}$

AMU-2006

Ans. (d) : Given,

$$\vec{A} = \hat{i} + \hat{j}$$

$$\vec{B} = \hat{i} + \hat{k}$$

Then

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{vmatrix}$$

$$\vec{A} \times \vec{B} = \hat{i}(1-0) - \hat{j}(1-0) + \hat{k}(0-1)$$

$$\vec{A} \times \vec{B} = \hat{i} - \hat{j} - \hat{k}$$

@apna_pdf

151. The (x, y, z) coordinates of two points A and B are given respectively as (0, 3, –1) and (–2, 6, 4). The displacement vector from A to B may be given by

(a) $-2\hat{i}+6\hat{j}+4\hat{k}$ (b) $-2\hat{i}+3\hat{j}+3\hat{k}$

(c) $-2\hat{i}+3\hat{j}+5\hat{k}$ (d) $2\hat{i}-3\hat{j}-3\hat{k}$

AMU-2005

Ans. (c) : $\vec{A}=a_1\hat{i}+a_2\hat{j}+a_3\hat{k}$

$$\vec{B}=b_1\hat{i}+b_2\hat{j}+b_3\hat{k}$$

Displacement vector $(\vec{r})=\vec{B}-\vec{A}$

$$(b_1-a_1)\hat{i}+(b_2-a_2)\hat{j}+(b_3-a_3)\hat{k}$$

Given,

$$\vec{A}=0\hat{i}+3\hat{j}-\hat{k}\text{ , }\vec{B}=-2\hat{i}+6\hat{j}+4\hat{k}$$

$$\therefore \vec{r}=\left(-2\hat{i}+6\hat{j}+4\hat{k}\right)-\left(3\hat{j}-\hat{k}\right)$$

$$\vec{r}=-2\hat{i}+3\hat{j}+5\hat{k}$$

152. $\vec{A}=4\hat{i}+4\hat{j}-4\hat{k}$ and $\vec{B}=3\hat{i}+\hat{j}+4\hat{k}$ then angle between vectors $\vec{A}$ and $\vec{B}$ is

(a) 180° (b) 90°

(c) 45° (d) 0°

AMU-2001

Ans. (b) : Given,

$$\vec{A}=4\hat{i}+4\hat{j}-4\hat{k}$$

$$\vec{B}=3\hat{i}+\hat{j}+4\hat{k}$$

Let θ be the angle between vector $\vec{A}$ and $\vec{B}$ then,

$$\cos\theta=\frac{\vec{A}.\vec{B}}{|\vec{A}||\vec{B}|}$$

$$\cos\theta=\frac{\left(4\hat{i}+4\hat{j}-4\hat{k}\right).\left(3\hat{i}+\hat{j}+4\hat{k}\right)}{\sqrt{4^2+4^2+(-4)^2}\sqrt{3^2+1^2+4^2}}$$

$$\cos\theta=\frac{12+4-16}{\sqrt{48}\sqrt{26}}$$

$$\cos\theta = 0 = \cos 90^\circ$$

$$\theta = 90^\circ$$

153. Consider the following statements about three vectors $\vec{a}, \vec{b}$ and $\vec{c}$ that have non-zero magnitudes. It follows $\vec{b}=\vec{c}$

(i) if $\vec{a}\cdot\vec{b}=\vec{a}\cdot\vec{c}$

(ii) if $\vec{a}\times\vec{b}=\vec{a}\times\vec{c}$ $\vec{b}$ must be perpendicular to $\vec{c}$

(a) (i) and (ii) both (b) neither (i) nor (ii)

(c) (i) only (d) (ii) only

AMU-2001

Ans. (c) : (i) $\vec{a}.\vec{b}=\vec{a}.\vec{c}$

$$\vec{a}\,\vec{b}\cos\theta=\vec{a}\,\vec{c}\cos\theta$$

Then $\vec{b}=\vec{c}$

(ii) $\vec{a}\times\vec{b}=\vec{a}\times\vec{c}$

$$|\vec{a}|\,|\vec{b}|\sin\theta=|\vec{a}|\,|\vec{c}|\sin\theta$$

$$|\vec{b}|=|\vec{c}|$$

$\vec{b}$ and $\vec{c}$ are equal in magnitude so, $\vec{b}$ and $\vec{c}$ are not perpendicular . they are parallel to each other.

So, only (i) is follows.

154. The angle between the vectors $\vec{A}=\hat{i}+\hat{j}$ and $\vec{B}=\hat{i}+\hat{j}+c\hat{k}$ is 30°.

Find the unknown c.

(a) 0 (b) ± 1

(c) $\pm\sqrt{\frac{2}{3}}$ (d) $\pm\frac{1}{2}$

AMU-2011

Ans. (c) : Given,

$$\vec{A}=\hat{i}+\hat{j},\ \vec{B}=\hat{i}+\hat{j}+c\hat{k},\ \ \theta=30^\circ$$

$$|\vec{A}|=\sqrt{(1)^2+(1)^2}=\sqrt{2}$$

$$|\vec{B}|=\sqrt{1^2+1^2+c^2}=\sqrt{2+c^2}$$

as we know that vector product is defined as,

$$\vec{A}\cdot\vec{B}=|\vec{A}|\cdot|\vec{B}|\cos\theta$$

$$\left(\hat{i}+\hat{j}\right)\cdot\left(\hat{i}+\hat{j}+c\hat{k}\right)=\sqrt{2}\times\left(\sqrt{2+c^2}\right)\cos 30^\circ$$

$$1+1=\sqrt{2}\times\left(\sqrt{2+c^2}\right)\times\frac{\sqrt{3}}{2}$$

$$\frac{4}{\sqrt{6}}=\sqrt{2+c^2}$$

$$2+c^2=\frac{16}{6}\Rightarrow c^2=\frac{4}{6}$$

$$c=\pm\sqrt{\frac{2}{3}}$$

155. The angle between $\vec{A}$ and the resultant of $2\vec{A}+3\vec{B}$ and $4\vec{A}-3\vec{B}$ is

(a) 90° (b) $\tan^{-1}\left(\frac{A}{B}\right)$

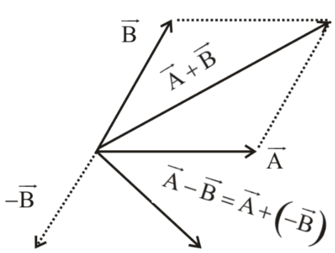
(c) $\tan^{-1}\left(\frac{B}{A}\right)$ (d) $\tan^{-1}\left(\frac{A-B}{A+B}\right)$

(e) 0°

Kerala CEE 2020

@apna_pdf

Ans. (e) : Consider $\vec{A}$ and $\vec{B}$,



Resultant of $2\vec{A}+3\vec{B}$ and $4\vec{A}-3\vec{B}$,

$(2\vec{A}+3\vec{B})+(4\vec{A}-3\vec{B}) = 2\vec{A}+3\vec{B}+4\vec{A}-3\vec{B} = 6\vec{A}$

Angle between $\vec{A}$ and resultant vector $(2\vec{A}+3\vec{B})$ and $(4\vec{A}-3\vec{B})$.

The angle between $\vec{A}$ and $6\vec{A}$ is 0°, because they are parallel vectors.

156. A particle moves from position $3\hat{i}+2\hat{j}+6\hat{k}$ to $14\hat{i}+13\hat{j}+9\hat{k}$ due to a uniform force of $4\hat{i}+\hat{j}+3\hat{k}$ newton. Find the work done if the displacement is in meters.

(a) 16 J (b) 64 J
(c) 32 J (d) 48 J

J&K CET- 2007

Ans. (b) : Given, $\vec{F} = 4\hat{i}+\hat{j}+3\hat{k}$

$d\vec{S} = (14\hat{i}+13\hat{j}+9\hat{k})-(3\hat{i}+2\hat{j}+6\hat{k})$

$=(11\hat{i}+11\hat{j}+3\hat{k})$

Work done $W = \vec{F}\cdot d\vec{S}$

$\therefore \quad W = (4\hat{i}+\hat{j}+3\hat{k})\cdot(11\hat{i}+11\hat{j}+3\hat{k})$

$W = 44+11+9$

$\therefore \quad W = 64J$

157. What is the linear velocity, if angular velocity vector $\omega = 3\hat{i}-4\hat{j}+\hat{k}$ and position vector $r = 5\hat{i}-6\hat{j}+6\hat{k}$?

(a) $6\hat{i}-2\hat{j}+3\hat{k}$ (b) $-18\hat{i}-13\hat{j}+2\hat{k}$
(c) $18\hat{i}+13\hat{j}+2\hat{k}$ (d) $6\hat{i}-2\hat{j}+8\hat{k}$

[AIPMT 1999]

Ans. (b) : Given,

$\omega = 3\hat{i}-4\hat{j}+\hat{k}$

$r = 5\hat{i}-6\hat{j}+6\hat{k}$

$$\vec{v} = (\vec{\omega}\times\vec{r}) = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -4 & 1 \\ 5 & -6 & 6 \end{vmatrix}$$

$=\hat{i}(-24+6)-\hat{j}(18-5)+\hat{k}(-18+20)$

$\boxed{\vec{v} = -18\hat{i}-13\hat{j}+2\hat{k}}$

158. When a particle moved from point A(2, 2, 3) to point B(6, 6, 9), its displacement vector is ____.

(a) $4\hat{i}+4\hat{j}+6\hat{k}$ (b) $8\hat{i}+8\hat{j}+12\hat{k}$
(c) $4\hat{i}+8\hat{j}+6\hat{k}$ (d) $8\hat{i}+4\hat{j}+6\hat{k}$

AP EAMCET-23.08.2021, Shift-I

Ans. (a) : Given,
The particle is moving from point
A (2, 2, 3) to the point B (6, 6, 9)
Displacement vector $(\vec{r}) = \Delta x\hat{i}+\Delta y\hat{j}+\Delta z\hat{k}$

$\vec{r} = (6-2)\hat{i}+(6-2)\hat{j}+(9-3)\hat{k}$

$\vec{r} = 4\hat{i}+4\hat{j}+6\hat{k}$

159. The position of a particle x (in meters) at a time t seconds is given by the relation $\vec{r} = (3t\hat{i}-t^2\hat{j}+4\hat{k})$. Calculate the magnitude of velocity of the particle after 5 seconds.

(a) 3.55 (b) 5.03
(c) 8.75 (d) 10.44

AMU-2010

Ans. (d) : Given,

$r = 3t\hat{i}-t^2\hat{j}+4\hat{k}$

$v = \frac{dr}{dt} = 3\hat{i}-2t\hat{j}+0$

$|v| = \sqrt{9+(-2t)^2}$

$= \sqrt{9+4t^2}$

Magnitude of velocity of particle t = 5 sec-

$|v| = \sqrt{9+4(5)^2}$

$|v| = \sqrt{9+100}$

$= 10.44$

160. The velocity of a moving particle at any instant is $\hat{i}+\hat{j}$. The magnitude and direction of the velocity of the particle are

(a) 2 units and 45° with the x-axis
(b) 2 units and 30° with the z-axis
(c) $\sqrt{2}$ units and 45° with the x-axis
(d) $\sqrt{2}$ units and 60° with the y-axis
(e) 2 units and 60° with the x-axis

Kerala CEE 2021

Ans. (c) : Given,
Velocity of moving particle is-
$v = \hat{i}+\hat{j}$

Then, magnitude $|v| = \sqrt{1^2+1^2}$

$v = \sqrt{2}$

Direction, $\cos\theta = \frac{A_x}{|\vec{A}|} = \frac{1}{\sqrt{1^2+1^2}} = \frac{1}{\sqrt{2}}$

$\theta = 45°$

So, the magnitude of velocity is $\sqrt{2}$ and direction 45° with the x-axis.

@apna_pdf

161. A certain vector in the xy-plane has an x-component of 4 m and a y-component of 10m. It is then rotated in the xy-plane so that its x-component is doubled. Then its new y-component is (approximately)

(a) 20m (b) 7.2m
(c) 5.0m (d) 4.5m

AP EAMCET -2011

Ans. (b) : Given that,

Initially : X – component = 4 m
Y – component = 10 m
Finally : X – component = 2 × 4 = 8 m
Y – component = y

The magnitude of vector do not change by its rotation
So,

$$\sqrt{4^2+10^2}=\sqrt{8^2+y^2}$$

$$y=\sqrt{52}$$

y = 7.2 m

162. A particle has an initial velocity 3i +4j and an acceleration of 0.4i +0.3 j. Its speed after 10 s is

(a) 10 units (b) $7\sqrt{2}$ units
(c) 7 units (d) 8.5 units

AIPMT-2010
AIEEE-2009

Ans. (b) : Given data,

$$u=3\hat{i}+4\hat{j}$$

$$a=0.4\hat{i}+0.3\hat{j}$$

t = 10 sec

we know that,

v = u + at

$$v=3\hat{i}+4\hat{j}+\left(0.4\hat{i}+0.3\hat{j}\right)\times 10$$

$$v=7\hat{i}+7\hat{j}$$

So, magnitude of $v=\sqrt{7^2+7^2}=7\sqrt{2}$

163. A particle moves from the point $\left(2.0\hat{i}+4.0\hat{j}\right)$m at t=0 with an initial velocity $\left(5.0\hat{i}+4.0\hat{j}\right)\text{ms}^{-1}$. It is acted upon by a constant force which produces a constant acceleration $\left(4.0\hat{i}+4.0\hat{j}\right)\text{ms}^{-2}$. What is the distance of the particle from the origin at time 2 s ?

(a) 5m (b) $20\sqrt{2}$m
(c) $10\sqrt{2}$m (d) 15m

JEE Main-11.01.2019, Shift-II

Ans. (b) : Given,

$S_{\text{initial}}=2.0\hat{i}+4.0\hat{j}$

$$u=5.0\hat{i}+4.0\hat{j}$$

$$a=4.0\hat{i}+4.0\hat{j}$$

Now,

$$\Delta s=ut+\frac{1}{2}at^2$$

$$S_{\text{Final}}-S_{\text{initial}}=ut+\frac{1}{2}at^2$$

$$S_{\text{Final}}-\left(2.0\hat{i}+4.0\hat{j}\right)=2\left(5.0\hat{i}+4.0\hat{j}\right)+\frac{1}{2}\left(4.0\hat{i}+4.0\hat{j}\right)(2)^2$$

$$S_{\text{Final}}=12\hat{i}+12\hat{j}+8\hat{i}+8\hat{j}$$

$$S_{\text{Final}}=20\hat{i}+20\hat{j}$$

$$|S_{\text{Final}}|=\sqrt{20^2+20^2}$$

$$|S_{\text{Final}}|=20\sqrt{2}\text{ m}$$

164. A particle is moving with a velocity $\mathbf{v}=k\left(y\hat{i}+x\hat{j}\right)$, where k is a constant. The general equation for its path is

(a) $y=x^2$ + constant (b) $y^2=x$ + constant
(c) xy = constant (d) $y^2=x^2$ + constant

JEE Main-09.01.2019, Shift-I
BITSAT- 2016
AIEE-2010

Ans. (d) : Given,

$$\vec{v}=ky\hat{i}+kx\hat{j} \quad \ldots(i)$$

General equation $\vec{v}=v_x\hat{i}+v_y\hat{j}$ …(ii)

Comparing eq^n (i) & (ii) we get

$v_x=ky,\ v_y=kx$

$$\frac{dx}{dt}=ky \quad \ldots(iii)$$

$$\frac{dy}{dt}=kx \quad \ldots(iv)$$

Now, eq^n (iv) / (iii)

$$\frac{dy/dt}{dx/dt}=\frac{kx}{ky}$$

$$\frac{dy}{dx}=\frac{x}{y}$$

$$\int y\,dy=\int x\,dx$$

$$\frac{y^2}{2}=\frac{x^2}{2}+\text{constant}$$

Or $y^2=x^2+\text{constant}$

165. In three dimensional system, the position coordinates of a particle (in motion) are given below

x = a cosωt, y = a sinωt, z = aωt

The velocity of particle will be

(a) $\sqrt{2}a\omega$ (b) $2a\omega$
(c) $a\omega$ (d) $\sqrt{3}a\omega$

JEE Main-09.01.2019, Shift-II

@apna_pdf

Ans. (a) : Given,

$$x = a\cos\omega t$$

$$v_x = \frac{dx}{dt} = -a\sin\omega t.\omega$$

Similarly

$$v_y = \frac{dy}{dt} = a\cos\omega t.\omega$$

$$v_z = \frac{dz}{dt} = a\omega$$

$$\therefore\ |v| = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

$$= \sqrt{(-a\omega\sin\omega t)^2 + (a\omega\cos\omega t)^2 + (a\omega)^2}$$

$$= \sqrt{a^2\omega^2 + a^2\omega^2}$$

$$= \sqrt{2}\,a\omega$$

166. Starting from the origin at time t =0, with initial velocity $5\hat{j}\ ms^{-1}$, a particle moves in the xy-plane with a constant acceleration of $(10\hat{i} + 4\hat{j})ms^{-2}$. At time t, its coordinates are (20m, y_0 m). The values of t and y_0 respectively, are

(a) 2 s and 18 m (b) 5 s and 25 m

(c) 2 s and 24 m (d) 4 s and 52 m

JEE Main-04.09.2020, Shift-I

Ans. (a) : Given data.

$$\vec{u} = 5\hat{j}\ m/s$$

$$\vec{a} = (10\hat{i} + 4\hat{j})m/s^2$$

Position coordinate (s) at time 't' = (20, y_0) ⇒ $20\hat{i} + y_0\hat{j}$

we know that,

second equation of motion is given by –

$$s = ut + \frac{1}{2}at^2$$

$$20\hat{i} + y_0\hat{j} = 5t\hat{j} + \frac{1}{2}(10\hat{i} + 4\hat{j})t^2$$

$$20\hat{i} + y_0\hat{j} = 5t\hat{j} + 5t^2\hat{i} + 2t^2\hat{j}$$

$$20\hat{i} + y_0\hat{j} = 5t^2\hat{i} + (5t + 2t^2)\hat{j}$$

compare x component of the position we get,

$20 = 5t^2$

t = 2 sec

compare y component of the position,

$y_0 = 5t + 2t^2$

$y_0 = 5 \times 2 + 2 \times 2^2$

$y_0 = 18$ m

167. The position vector of particle changes with time according to the relation $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$. What is the magnitude of the acceleration (in ms^{-2}) at t =1?

(a) 50 (b) 100

(c) 25 (d) 40

JEE Main-09.04.2019, Shift-II

Ans. (a) : $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$

$$\frac{d\vec{r}(t)}{dt} = \vec{v}(t)$$

$$\vec{v}(t) = 30t\hat{i} + (0 - 40t\hat{j})$$

$$\vec{v}(t) = 30t\hat{i} - 40t\hat{j}$$

$$\frac{d\vec{v}(t)}{dt} = \vec{a}(t) = 30\hat{i} - 40\hat{j}$$

$$|a| = \sqrt{30^2 + (-40)^2} = 50\,m/s^2$$

168. Consider a particle moving in the xy plane with velocity $\vec{v} = a\hat{i} + bx\hat{j}$, where $\hat{i}$ and $\hat{j}$ are the unit vectors along x and y axes and 'a' and 'b' are constants. If the initial position of the particle is x = y = 0. The equation to describe the particle's trajectory in the plane is

(a) $y = \frac{b}{2a}x^2$ (b) $y = x^2$

(c) $y = \frac{b}{a}x$ (d) $y = \frac{2b}{a}x^2$

TS EAMCET 08.05.2019, Shift-II

Ans. (a) : Given,

velocity $\vec{v} = a\hat{i} + bx\hat{j}$

Initial position , x = 0 , y = 0

Here, $v_x = a$

$$\frac{dx}{dt} = a$$

$$v_y = bx$$

$$\frac{dy}{dt} = bx$$

$$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{bx}{a}$$

$$\frac{dy}{dx} = \frac{bx}{a}$$

$$dy = \frac{b}{a}x\,dx$$

Integrating both side,

$$\int_0^y dy = \int_0^x \frac{b}{a}x\,dx$$

$$y = \frac{b}{a}\frac{x^2}{2}$$

$$y = \frac{b}{2a}x^2$$

169. A particle moves over a xy plane with a constant acceleration $\vec{a} = (4.0m/s^2)\hat{i} + (4.0m/s^2\hat{j})$. At time t = 0, the velocity is $(4.0m/s^2)\hat{i}$. The speed of the particle when it is displaced by 6.0 m parallel to the x-axis is

@apna_pdf

(a) $4\sqrt{5}$ m/s (b) $\sqrt{60}$ m/s

(c) $3\sqrt{10}$ m/s (d) $\sqrt{20}$ m/s

TS EAMCET 04.08.2021, Shift-I

Ans. (a) : Use equation of motion

Apply second equation of Motion–

Given that,

$t = 0,\ u = 4\hat{i}$

$u_x = 4$

$$\vec{a} = \left(4\hat{i} + 4\hat{j}\right) m/s^2$$

$$a_x = 4 m/s^2, a_y = 4 m/s^2$$

$$s_x = u_x t + \frac{1}{2} a_x t^2$$

$$6 = 4t + \frac{1}{2} \times 4 \times t^2$$

$$2t^2 + 4t - 6 = 0$$

$$t^2 + 2t - 3 = 0$$

$$t^2 + 3t - t - 3 = 0$$

$$t(t+3) - 1(t+3) = 0$$

$$t + 3 = 0$$

$$t - 1 = 0$$

$$t = 1 \text{ sec}, \quad t = -3 \text{ (not possible)}$$

So,

$$t = 1$$

Velocity of particle–

$$\vec{v} = \vec{u} + \vec{a}t$$

$$\vec{v} = (4\hat{i} + 0\hat{j}) + (4\hat{i} + 4\hat{j}) \times 1$$

$$= 4\hat{i} + 4\hat{i} + 4\hat{j}$$

$$\vec{v} = 8\hat{i} + 4\hat{j}$$

Speed of particle-

$$|\vec{v}| = \sqrt{(8)^2 + (4)^2}$$

$$= \sqrt{64 + 16}$$

$$|\vec{v}| = \sqrt{80}$$

$$= \sqrt{4 \times 4 \times 5}$$

$$|\vec{v}| = 4\sqrt{5} \text{ m/s}$$

170. A bullet of mass 0.05 kg moving with a speed of 80 ms^{-1} enters a wooden block and is stopped after a distance of 0.40 m. The average resistive force exerted by the block on the bullet is

(a) 300 N (b) 20 N

(c) 400 N (d) 40 N

(e) 200 N

Kerala CEE - 2008

Ans. (c) : Given that, $m = 0.05$ kg, $u = 80$ m/s

$v = 0,\ s = 0.4$m

We know that,

$$v^2 = u^2 - 2as$$

$$0 = (80)^2 - 2a(0.40)$$

$$a = \frac{80 \times 80}{2 \times (0.40)}$$

$$a = 8000 \text{ m/s}^2$$

According to Newton's second law

$$F = ma$$

$$= 0.05 \times 8000$$

$$= 400 \text{ N}$$

171. A particle is moving in the x-y plane and its coordinates at any time t are given by

x = 5 cos ωt

y = 5 sin ωt

Where (ω) = $\frac{\pi}{4}$ rad/s. The direction of force it experiences at t = 3s is.

(a) $\hat{i} + \hat{j}$ (b) $\hat{i} - \hat{j}$

(c) $\hat{i}$ (d) $\hat{j}$

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (b) : Given,

$$\omega = \frac{\pi}{4}$$

$$x = 5 \cos \omega t$$

$$\frac{dx}{dt} = v_x = -5\omega \sin \omega t$$

$$\frac{dv_x}{dt} = a_x = -5\omega^2 \cos \omega t$$

a_x at $t = 3$

$$a_x = -5\left(\frac{\pi}{4}\right)^2 \cos(135^\circ)$$

$$a_x = -5\left(\frac{\pi}{4}\right)^2 \left(-\frac{1}{\sqrt{2}}\right)$$

$$a_x = +\frac{5}{\sqrt{2}}\left(\frac{\pi}{4}\right)^2 \text{ along } x\,(\hat{i})$$

$$y = 5 \sin \omega t$$

$$\frac{dy}{dt} = v_y = 5 \cos \omega t$$

$$\frac{dv_y}{dt} = a_y = -5\omega^2 \sin \omega t$$

a_y at $t = 3$

$$a_y = -5\left(\frac{\pi}{4}\right)^2 \sin(135^\circ)$$

$$a_y = -5\left(\frac{\pi}{4}\right)^2 \left(\frac{1}{\sqrt{2}}\right)$$

$$a_y = -\frac{5}{\sqrt{2}}\left(\frac{\pi}{4}\right)^2 \text{ along } y\,(-\hat{j})$$

Direction of net accl..

$$= +\hat{i} - \hat{j}$$

$$= \hat{i} - \hat{j}$$

@apna_pdf

(b) Plane Motion Analysis

172. A man is walking due east at the rate of 2 km/h. The rain appears to him to come down vertically at the rate of 2 km/h. The actual velocity and direction of rainfall with the vertical respectively are

(a) $2\sqrt{2}$ km/h, 45°
(b) $\frac{1}{\sqrt{2}}$ km/h, 30°
(c) 2km/h, 0°
(d) 1 km/h, 90°

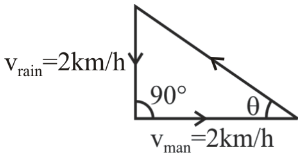
AP EMCET(Medical)-2008

Ans. (a) : The velocity of rain appearing to man is relative velocity of rain with respect to man,

$$\vec{v}_{rm} = \vec{v}_m - \vec{v}_r$$
$$= 2\hat{i} - \left(-2\hat{j}\right)$$
$$\vec{v}_{rm} = 2\hat{i} + 2\hat{j}$$
$$|\vec{v}_{rm}| = \sqrt{(2)^2 + (2)^2}$$
$$= \sqrt{8}$$

Magnitude of velocity $|\vec{v}_{rm}| = 2\sqrt{2} =$ km/h

For direction,



$$\tan\theta = \frac{P}{B} = \frac{v_{rain}}{v_{man}} = \frac{2}{2} = 1$$

⇒ $\theta = \tan^{-1}(1)$

⇒ $\theta = 45°$

173. The initial velocity of a particle, $\vec{u} = 4\hat{i} + 3\hat{j}$. It is moving with uniform acceleration $\vec{a} = 0.4\hat{i} + 0.3\hat{j}$. Its velocity after 10 seconds is:

(a) 3 unit
(b) 4 unit
(c) 5 unit
(d) 10 unit

AP EAMCET(Medical)-2001

Ans. (d) : Given,

$$\vec{u} = 4\hat{i} + 3\hat{j}$$
$$\vec{a} = 0.4\hat{i} + 0.3\hat{j}$$

Velocity of x-component

$$\vec{v}_x = \vec{u}_x + \vec{a}_x t$$
$$= 4\hat{i} + \left(0.4\hat{i}\right) \times 10$$
$$= 8\hat{i}\ \text{m/s}$$

Velocity of y-component

$$\vec{v}_y = \vec{u}_y + \vec{a}_y t$$
$$= 3\hat{j} + \left(0.3\hat{j}\right) \times 10$$
$$= 6\hat{j}\ \text{m/s}$$

Total velocity $\vec{v} = \vec{v}_x + \vec{v}_y$

$$\vec{v} = (8\hat{i} + 6\hat{j})\text{m/s}$$

∴ Magnitude of total velocity $|\vec{v}| = \sqrt{{v_x}^2 + {v_y}^2}$

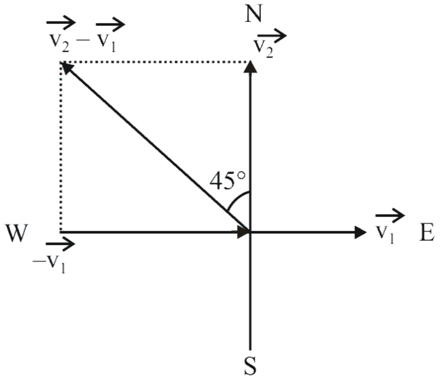
$$|\vec{v}| = \sqrt{(8)^2 + (6)^2} = \sqrt{100} = 10\,\text{unit}$$

174. A particle is moving eastwards with a velocity of 15 m/s. In a time of 10 s, the velocity changes to 15 m/s northwards. Average acceleration during this time is, in m/s^2.

(a) $\frac{3}{\sqrt{2}}$
(b) $3\sqrt{2}$ north-east
(c) $\frac{3}{\sqrt{2}}$ north-west
(d) $3\sqrt{2}$ north-west

AP EAMCET(Medical)-1997

Ans. (c) :



Given,

$$\vec{v}_1 = -15\hat{i}, v_2 = 15\hat{j}$$
$$\Delta\vec{v}_{12} = \vec{v}_2 - \vec{v}_1 = \vec{v}_2 - \left(-\vec{v}_1\right)$$
$$\Delta\vec{v}_{12} = 15\hat{j} + 15\hat{i}$$
$$\vec{a}_{avg} = \frac{\Delta\vec{v}_{12}}{\Delta t} = \frac{15\hat{j} + 15\hat{i}}{10} = \frac{3}{2}\hat{j} + \frac{3}{2}\hat{i}$$
$$|\vec{a}_{avg}| = \sqrt{\left(\frac{3}{2}\right)^2 + \left(\frac{3}{2}\right)^2} = \frac{3}{\sqrt{2}}\ \text{m/s}^2$$

Average acceleration is $\frac{3}{\sqrt{2}}$ m/s^2 along north-west.

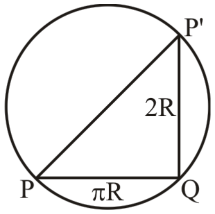
175. A wheel of radius 2 cm is at rest on the horizontal surface. A point P on the circumference of the wheel is in contact with the horizontal surface. When the wheel rolls without slipping on the surface, the displacement of point P after half rotation of wheel is

(a) $2\left(\pi^2 + 2\right)^{\frac{1}{2}}$ cm
(b) $\left(\pi^2 + 2\right)^{\frac{1}{2}}$ cm
(c) $\left(\pi^2 + 4\right)^{\frac{1}{2}}$ cm
(d) $2\left(\pi^2 + 4\right)^{\frac{1}{2}}$ cm

MHT-CET 2020

@apna_pdf

Ans. (d) :



Given, radius of wheel R = 2 cm

After half the rotation $= \dfrac{\text{Circumference of the wheel}}{2}$

$= \dfrac{2\pi R}{2}$

Then, $PQ = \pi R$

and $P'Q = 2R$ (vertical distance)

In $\Delta P'QP$

$PP'^2 = PQ^2 + P'Q^2$

$PP' = \sqrt{PQ^2 + P'Q^2}$

$PP' = \sqrt{\pi^2 R^2 + 4R^2} \quad = R\sqrt{\pi^2 + 4}$

$= 2\sqrt{\pi^2 + 4}$ cm

$\therefore$ Displacement $PP' = 2\left(\pi^2 + 4\right)^{\frac{1}{2}}$ cm

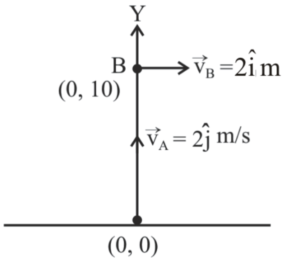
176. Two persons A and B are located in X-Y plane at the points (0, 0) and (0, 10) respectively. (The distances are measured in MKS unit). At a time t=0, they start moving simultaneously with velocities $\vec{v}_a = 2\hat{j}$ ms^{-1} and $\vec{v}_b = 2\hat{i}$ ms^{-1} respectively. The time after which A and B are at their closest distance is

(a) 2.5s (b) 4s

(c) 1s (d) $\dfrac{10}{\sqrt{2}}$s

VITEEE-2009

Ans. (a) : After the time (t) the position of A is $(0, v_A t)$ and position of B = $(v_B t, 10)$. Distance between them.



$y = \sqrt{(0 - v_B t)^2 + (v_A t - 10)^2}$ (by distance formula)

$y^2 = (2t)^2 + (2t - 10)^2$

$y^2 = l = 4t^2 + 4t^2 + 100 - 40t$ (Let, $y^2 = l$)

$l = 8t^2 + 100 - 40t$ .....(i)

Differentiating both side with respect to t

$\dfrac{dl}{dt} = (16t - 40)$ .....(ii)

$\dfrac{d^2 l}{dt^2} = 16 = +ve$ (i.e. l will be minimum)

For minimum condition, $\dfrac{dl}{dt} = 0$

$16t - 40 = 0$

$\therefore \; t = \dfrac{40}{16} = 2.5\,\text{sec}$

Hence, t = 2.5sec after which A and B are at their closest distance.

177. The position vector of a particle is $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$. The velocity of the particle is

(a) directed towards the origin
(b) directed away from the origin
(c) parallel to the position vector
(d) perpendicular to the position vector

BITSAT-2006

Ans. (d) : Position vector $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$

Thus velocity vector

$\vec{v} = \dfrac{d\vec{r}}{dt} = (-a\omega\sin\omega t)\hat{i} + (a\omega\cos\omega t)\hat{j}$

For direction of $\vec{v}$ w.r.t. $\vec{r}$

$\vec{v}\cdot\vec{r} = \left[(-a\omega\sin\omega t)\hat{i} + (a\omega\cos\omega t)\hat{j}\right]\cdot\left[(a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}\right]$

$\therefore \vec{v}\cdot\vec{r} = -a^2\omega\sin\omega t\cdot\cos\omega t + a^2\omega\sin\omega t\cdot\cos\omega t = 0$

$\vec{v}.\vec{r} = 0$

So, velocity vector is perpendicular to the position vector.

178. Speeds of two identical cars are u and 4u at a specific instant. The ratio of the respective distance in which the two cars are stopped in the same time

(a) 1 : 1 (b) 1 : 4

(c) 1 : 8 (d) 1 : 16

CG PET- 2006

Ans. (d) : Given that,

Speed of first car $(u_1) = u$

Speed of second car $(u_2) = 4u$

According to third law of motion,

$v^2 = u^2 - 2as$

Here, $v = 0$

$(0)^2 = u^2 - 2as$

$s = \dfrac{u^2}{2a}$

Let distance travelled by

First car $s_1 = \dfrac{(u_1)^2}{2a}, s_2 = \dfrac{(u_2)^2}{2a}$

$s_1 = \dfrac{u^2}{2a}$ .....(i)

and for second car $s_2 = \dfrac{(4u)^2}{2a} = \dfrac{16u^2}{2a}$ .....(ii)

on dividing equation (i) & (ii) , we get

$\dfrac{s_1}{s_2} = \dfrac{1}{16}$

So, the ratio is 1: 16

@apna_pdf

179. The magnitude of acceleration and velocity of a particle moving in a plane, whose position vector $\vec{r} = 3t^2\hat{i} + 2t\hat{j} + \hat{k}$ at t=2s are respectively

(a) $\sqrt{148}, 6$ (b) $\sqrt{144}, 6$

(c) $\sqrt{13}, 3$ (d) $\sqrt{14}, 3$

TS-EAMCET-04.05.2018, Shift-1

Ans. (a) : Given, position vector $\vec{r} = 3t^2\hat{i} + 2t\hat{j} + \hat{k}$

First we have to find vector of velocity

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt}\left[3t^2\hat{i} + 2t\hat{j} + \hat{k}\right]$$

$$\vec{v} = 6t\hat{i} + 2\hat{j}$$

Magnitude of velocity at $t = 2s$

$$\vec{v} = 6(2)\hat{i} + 2\hat{j}$$

$$\vec{v} = 12\hat{i} + 2\hat{j}$$

$$|\vec{v}| = \sqrt{144 + 4} = \sqrt{148}$$

$$a = \frac{d\vec{v}}{dt} = \frac{d}{dt}\left(6t\hat{i} + 2\hat{j}\right)$$

$$a = 6\hat{i}$$

$$|\vec{a}| = 6$$

180. A 4 kg object has a velocity, $3.0\hat{i}$ m/s at some instant. 8 seconds later, its velocity is $\left(8.0\hat{i} + 10.0\hat{j}\right)$ m/s. Assuming that the object is subjected to a constant net force, the magnitude of the force is

(a) $\frac{5\sqrt{5}}{2}$N (b) $\frac{5\sqrt{3}}{8}$N

(c) $\frac{8\sqrt{5}}{3}$N (d) $\frac{10\sqrt{3}}{7}$N

TS-EAMCET-04.05.2019, Shift-1

Ans. (a) : Given that, m = 4 kg, u = $3\hat{i}$ m/s, $v = \left(8\hat{i} + 10\hat{j}\right)$, t = 8s

Equation of motion is

$$v = u + at \Rightarrow \left(8\hat{i} + 10\hat{j}\right) = 3\hat{i} + a \times 8$$

$$a = \left(\frac{5\hat{i} + 10\hat{j}}{8}\right) m/s^2$$

Force F = ma

$$= 4 \times \left(\frac{5\hat{i} + 10\hat{j}}{8}\right)$$

$$F = \frac{5}{2}\hat{i} + 5\hat{j}$$

Magnitude of force $|F| = \sqrt{\left(\frac{5}{2}\right)^2 + (5)^2}$

$$= \sqrt{\frac{25}{4} + 25}$$

$$= 5\sqrt{\frac{5}{4}} = \frac{5\sqrt{5}}{2}N$$

181. The position vector of a particle moving in a plane is given by $r = a\cos\omega t\,\hat{i} + b\sin\omega t\,\hat{j}$ where $\hat{i}$ and $\hat{j}$ are the unit vectors along the rectangular axes X and Y; a, b, and ω are constants and t is time. The acceleration of the particle is directed along the vector

(a) $-a\hat{i} + b\hat{j}$ (b) $b\hat{i} + a\hat{j}$

(c) $-r$ (d) $\frac{dr}{dt}$

TS-EAMCET-07.05.2018, Shift-1

Ans. (c) : Given,

$r = a\cos\omega t\,\hat{i} + b\sin\omega t\,\hat{j}$ .....(i)

On differentiating w.r.t. t, we get

$$\frac{dr}{dt} = v = -a\,\omega\sin\omega t\,\hat{i} + b\,\omega\cos\omega t\,\hat{j}$$

$$a = \frac{dv}{dt}$$

$a = -\omega^2\left(a\cos\omega t\,\hat{i} + b\sin\omega t\,\hat{j}\right)$ .....(ii)

Putting value of equation (i) in (ii), we get

$$a = -\omega^2 r$$

$$a.r \neq 0$$

So, $\vec{a}$ is not perpendicular to $\vec{r}$ and –ve show that acceleration is toward the origin. So, that the acceleration of the particle directed along the vector –r.

182. A particle moves in XY-plane with *x* and y varying with time t as x(t) = 5t, y(t) = 5t (27 – t^2). At what time in seconds, the direction of velocity and acceleration will be perpendicular to each other?

(a) $5\sqrt{\frac{27}{2}}$ (b) 5

(c) $5\sqrt{12}$ (d) 3

TS-EAMCET-05.05.2018, Shift-2

Ans. (d) : velocity in x–direction is v_x

$$v_x = \frac{dx}{dt}$$

$$v_x = \frac{d}{dt}(5t) = 5ms^{-1}$$

velocity in y –direction is v_y

$$v_y = \frac{dy}{dt} = \frac{d}{dt}\left(5 \times 27t - 5t^3\right)$$

$$= 5 \times 27 - 15t^2$$

$$= 135 - 15t^2$$

∵ this case similar to projectile motion velocity and acceleration are perpendicular, when $v_y = 0$

$$\Rightarrow \quad 135 - 15t^2 = 0$$

$$15t^2 = 135$$

$$t^2 = 9$$

$$t = \sqrt{9}$$

$$t = 3s$$

@apna_pdf

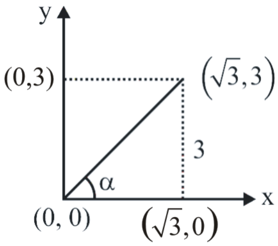
183. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are $(\sqrt{3},3)$. The path of the particle makes with the x-axis an angle of

(a) 30º (b) 45º

(c) 60º (d) 0º

JCECE-2008

Ans. (c) : Let, α be the angle which particle makes with an x–axis



From the above figure.

$$\tan\alpha = \frac{y}{x} = \frac{3}{\sqrt{3}} = \sqrt{3}$$

$$\tan\alpha = \sqrt{3} = \tan 60°$$

$$\alpha = 60°$$

184. A particle is moving eastward with velocity 5ms^{-1}. In 10s the velocity changes to 5ms^{-1} northwards. The average acceleration in this time is

(a) $\frac{1}{\sqrt{2}}\text{ms}^{-2}$ towards North-West

(b) $\frac{1}{2}\text{ms}^{-2}$ towards North-West

(c) $\frac{1}{\sqrt{2}}\text{ms}^{-2}$ towards North-East

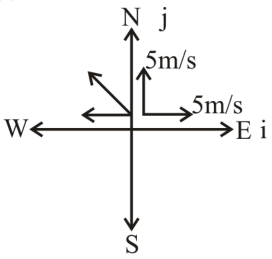
(d) $\frac{1}{2}\text{ms}^{-2}$ towards North-East

COMEDK 2012

Ans.(a): Given, initial velocity $v_1 = 5\hat{i}$ m/s eastwards

Final velocity $v_2 = 5\hat{j}$ m/s northwards

Time (t) = 10 sec



$$|\text{Average acceleration}| = \frac{|\Delta v_{12}|}{t}$$

$$= \frac{|v_2 - v_1|}{t} = \frac{|5j - 5i|}{t}$$

$$= \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\text{m/s}^2 \text{ towards North-West}$$

185. Assertion: The magnitude of velocity of two boats relative to river is same. Both boats start simultaneously from same point on one bank may reach opposite bank simultaneously moving along different paths.

Reason: For boats to cross the river in same time. The component of their velocity relative to river in direction normal of flow should be same.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-2015

Ans. (a) : Here, both assertion and reason are correct and reason is the correct explanation of assertion. For boats to cross the river in same time, the component of their velocity relative to river is normal to river flow should be. This component velocity of boats is responsible for reaching the bank of the river simultaneously.

186. Assertion: The driver in a vehicle moving with a constant speed on a straight road is an inertial frame of reference.

Reason: A reference frame in which Newton's laws of motion are applicable is non-inertial.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-2009

Ans. (c) : Here, assertion is correct but reason is wrong. A vehicle moving with constant velocity on a straight road is an inertial frame of reference. But, a reference frame in which Newton's laws of motion are applicable is known as inertial frame.

A reference frame in which Newton's laws of motion are not applicable is known as Non-inertial frame of reference. Example: Rotational frame of reference.

187. A block of mass 1 kg starts from rest at x = 0 and moves along the X-axis under the action of a force F = kt, where t is time and k = 1 Ns^{-1}. The distance the block will travel in 6 seconds is

(a) 36 m (b) 72 m

(c) 108 m (d) 18 m

WB JEE 2017

@apna_pdf

Ans. (a) : Given,

$F = kt$, $m = 1\text{kg}$, $k = 1\text{Ns}^{-1}$, $t = 6$ sec

$F = ma$

$\therefore\ ma = kt$

$1 \times a = kt$

$a = kt$

$$\frac{dv}{dt} = kt \qquad \left\{\because a = \frac{dv}{dt}\right\}$$

$dv = k\,tdt$

Integrating both side,

$$\int dv = \int k\,tdt$$

$$v = k\frac{t^2}{2}$$

$$\frac{dx}{dt} = k\frac{t^2}{2} \qquad \left\{\because v = \frac{dx}{dt}\right\}$$

$$dx = k\frac{t^2}{2}.dt$$

Again Integrating both side,

$$\int dx = \int k\frac{t^2}{2}.dt = \frac{k}{2}\frac{t^3}{3} = \frac{kt^3}{6}$$

At $t = 6$

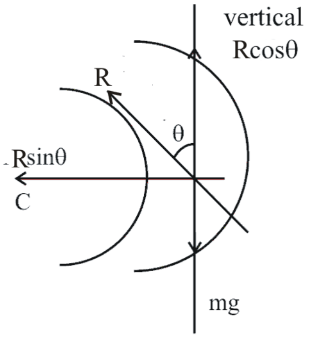
$$x = k\frac{t^3}{6} = 1\times\frac{6^3}{6} = 36\,\text{m}$$

188. A cyclist is moving along a curvature of radius 'r' at a constant speed 'v'. The angle made by the cyclist with the vertical plane is

(a) $\tan^{-1}\left(\frac{v^2}{rg}\right)$
(b) $\tan^{-1}\left(\frac{rg}{v^2}\right)$
(c) $\tan^{-1}\left(\frac{v^2r}{g}\right)$
(d) $\tan^{-1}\left(\frac{r}{v^2g}\right)$

WB JEE-2007

Ans. (a) : From Newton's second law,



$\therefore$ Vertical component

$mg = R\cos\theta$ …(i)

Horizontal component

Centripetal Force,

$F_c = R\sin\theta$

$$\frac{mv^2}{r} = R\sin\theta \qquad \text{…(ii)}$$

Equation (ii) divided by eq^n (i)

$$\frac{\frac{mv^2}{r}}{mg} = \frac{R\sin\theta}{R\cos\theta}$$

$$\tan\theta = \frac{v^2}{rg}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)}$$

189. A boat crosses a river with a velocity of 8 km/h. If the resulting velocity of boat is 10 km/h, then the velocity of river water is

(a) 4 km/h
(b) 6 km/h
(c) 8 km/h
(d) 10 km/h

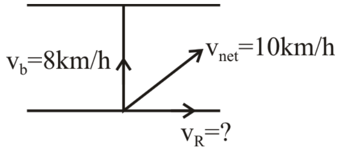
UP CPMT-2001

Ans. (b) :

Resulting velocity of boat (u_{net}) = 10 km/hr

velocity of boat (u_b) = 8 km/hr

We know that,



$$\vec{u}_{net} = \vec{u}_b + \vec{u}_r$$

$$|\vec{u}_{net}| = \sqrt{u_b^2 + u_r^2}$$

$$10 = \sqrt{(8)^2 + u_r^2}$$

$$100 = 64 + u_r^2$$

$u_r = 6$ km/h

190. An aircraft is flying at a height of 'H' above the ground and at a speed of 'V'. The maximum angle subtended at a ground observation point by the aircraft after time T is

(a) $\tan^{-1}\left(\frac{VT}{H}\right)$
(b) $\tan^{-1}\left(\frac{VT}{2H}\right)$
(c) $2\tan^{-1}\left(\frac{2VT}{H}\right)$
(d) $2\tan^{-1}\left(\frac{VT}{2H}\right)$

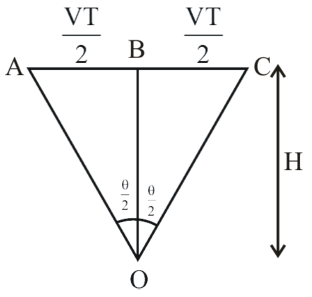
TS EAMCET 19.07.2022, Shift-I

Ans. (d) : Given,

Aircraft is flying at a height = H

Speed of aircraft = V

Time = T.



@apna_pdf

Let A, B , and C denotes the position of aircraft as it flies above the observation point O and the angle subtend here is θ from end to end.

Using triangle geometry in ΔAOB

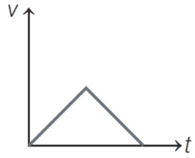
$$\tan\frac{\theta}{2}=\frac{AB}{BO}$$

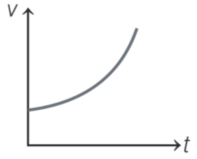
$$\tan\frac{\theta}{2}=\frac{VT}{2H}$$

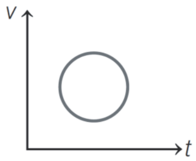
$$\frac{\theta}{2}=\tan^{-1}\left(\frac{VT}{2H}\right)$$

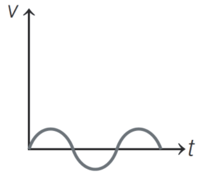
$$\theta=2\tan^{-1}\left(\frac{VT}{2H}\right)$$

191. Which of the following curves does not represent motion in one dimension?

(a)


(b)


(c)


(d)


[AIPMT 1992]

Ans. (c) : Velocity of body can be positive as well as negative because change in position can be positive or negative. However, time is always in forward direction. Therefore, a body can never go back in time.

In graph C, we can see that the body has two different velocity at a given time. therefore, this graph does not represent the motion of a moving body.

192. Two boys are standing at the ends A and B of a ground, where AB = a. The boy at B starts running in a direction perpendicular to AB with velocity v_1 The boy at A starts running simultaneously with velocity v and catches the other boy in a time t, where t is

(a) $\dfrac{a}{\sqrt{v^2+v_1^2}}$

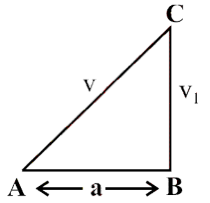
(b) $\sqrt{\dfrac{a^2}{v^2-v_1^2}}$

(c) $\dfrac{a}{v-v_1}$

(d) $\dfrac{a}{v+v_1}$

JIPMER-2013

Ans. (b): Let two boys meet at point C after time 't' from the starting,



AC = vt and BC = v_1t

We know that,

$$(AC)^2 = (AB)^2 + (BC)^2$$

$$v^2t^2 = a^2 + v_1^2t^2$$

$$v^2t^2 - v_1^2t^2 = a^2$$

$$t^2\left(v^2-v_1^2\right) = a^2$$

$$t=\sqrt{\frac{a^2}{v^2-v_1^2}}$$

193. A block of mass 2 kg moving on a horizontal surface with speed of 4 ms^{-1} enters a rough surface ranging from x=0.5 m to x=1.5m. The retarding force in this range of rough surface is related to distance by F=kx where k=12 Nm^{-1}. The speed of the block as it just crosses the rough surface will be:

(a) Zero
(b) 1.5 ms^{-1}
(c) 2.0 ms^{-1}
(d) 2.5 ms^{-1}

JEE Main-28.06.2022, Shift-II

Ans. (c) : Given data,

m = 2 kg, v = 4 m/s

surface range (x) = 0.5 to 1.5 m

k = 12 N/m

F = –kx (F = ma)

ma = –kx

$$a=\frac{-kx}{m}=-\frac{12\times x}{2}$$

$$a=-6x$$

$$v\frac{dv}{dx}=-6x$$

$$\int_4^v v\,dv=-\int_{0.5}^{1.5}6x\,dx$$

$$\left[\frac{v^2}{2}\right]_4^v=-6\left[\frac{x^2}{2}\right]_{0.5}^{1.5}$$

$$\left(\frac{v^2-16}{2}\right)=-\frac{6}{2}\left[1.5^2-0.5^2\right]$$

$$\frac{v^2-16}{2}=-3\times2$$

$$v^2=-12+16$$

$$v^2=4 \Rightarrow v=2m/s$$

@apna_pdf

(c) Relative Velocity in Plane

194. The speed of a swimmer is 4 kmh^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750 m down the stream on the opposite bank.

The speed of the river water is _____ km h^{-1}

JEE Main-31.01.2023, Shift-I

Ans. (3) : Given, width of river = 1 km

Speed of swimmer = 4 km h^{-1}

Time to cross the river (t) = $\frac{1}{4} = 0.25\,\text{hr}$

Reaches a point 750 m down the stream on the opposite bank,

Velocity of river (v) $= \frac{750\times10^{-3}}{0.25} = 3$ km/h

195. A boat is moving with a velocity $3\hat{i}+4\hat{j}$ with respect to ground the water in the river is moving with a velocity $-3\hat{i}-4\hat{j}$ w.r.t. ground. The relative velocity of boat w.r.t. water is

(a) $5\hat{i}+6\hat{j}$ (b) $6\hat{i}+8\hat{j}$

(c) $6\hat{i}+8\hat{k}$ (d) $5\hat{j}-6\hat{k}$

EAMCET-1991

Ans. (b) : Given,

Velocity of boat = $(3\hat{i}+4\hat{j})$

The water in the river is moving with a velocity $-3\hat{i}-4\hat{j}$ with respect to ground.

∴ Relative velocity of boat with respect to water is.

$$v_{boat} - v_{water} = (3\hat{i}+4\hat{j}) - (-3\hat{i}-4\hat{j})$$
$$= (3\hat{i}+4\hat{j}) + 3\hat{i}+4\hat{j}$$
$$= 3\hat{i}+4\hat{j}+3\hat{i}+4\hat{j}$$
$$= 6\hat{i}+8\hat{j}$$

196. A boat which has a speed of 13 km/h in still water, crosses a river of width 1 km along the shortest possible path in 12 minute. the velocity of the river water in km/h is:

(a) 12 (b) 10

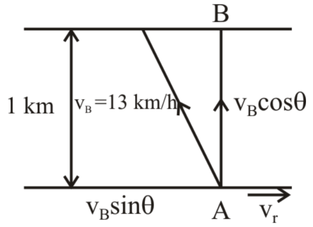
(c) 8 (d) 6

AP EAMCET(Medical)-2002

Ans. (a) : Given that,

Speed of boat 13 km/h in still water.

A river of width 1 km along the shortest possible path in 12 minute.



Therefore,

Speed of boat relative to ground

$$= \frac{1}{\left(\frac{12}{60}\right)}\text{km/h}$$
$$= \frac{60}{12} = 5\text{km/h}$$

Now,

$5^2 = 13^2 - x^2$ (where, x is speed of water)

⇒ $25 - 169 = -x^2$

⇒ $144 = x^2$

⇒ $x = 12$ km/h

197. A gun mounted on the top of a moving truck is aimed in the backward direction at an angle of 30° to the vertical. If the muzzle velocity of the gun is 4m/s, the value of the speed of the truck that will make the bullet come out vertically is :

(a) 1m/s (b) $\frac{\sqrt{3}}{2}$m/s

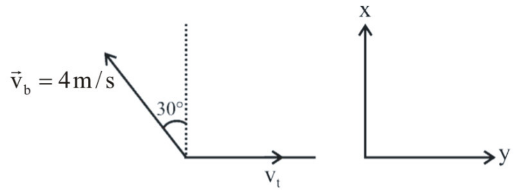
(c) 0.5 m/s (d) 2m/s

AP EAMCET(Medical)-1998

Ans. (d) : Given that, Angle in backward direction = 30°

Muzzle velocity of bullet = 4 m/s

For bullet to come out vertically



$v_b \sin30° = v_t$

$4\times\frac{1}{2} = v_t \Rightarrow \frac{4}{2} = v_t \Rightarrow v_t = 2$ m/s

198. A person swims in a river aiming to reach exactly on the opposite point on the bank of a river. His speed of swimming is 0.5 m/s at an angle of 120° with the direction of flow of water. The speed of water is

(a) 1.0 m/s (b) 0.5 m/s

(c) 0.25 m/s (d) 0.43 m/s

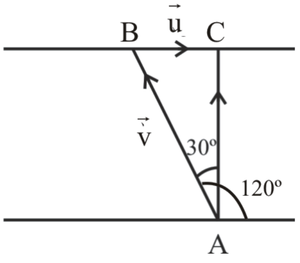
VITEEE-2019

AIIMS-26.05.2018(E)

CBSE AIPMT-1999

Ans. (c) : Speed of water = $\vec{u}$

Speed of swimmer = $\vec{v}$ = 0.5 m/s



Angle between $\vec{v}$ and $\vec{u}$ is 120° then

@apna_pdf

$$\sin\theta = \frac{\vec{u}}{\vec{v}} \Rightarrow \sin 30^\circ = \frac{u}{0.5}$$

$$\frac{1}{2} = \frac{u}{0.5}$$

$u = 0.25$ m/s

199. A rain drop of radius 0.3 mm has a terminal velocity in air is 1 m/s. The viscosity of air is 8× 10^{-5} poise. The viscous force on it is

(a) 45.2×10^{-4} dyne (b) 101.73×10^{-5} dyne
(c) 16.95×10^{-4} dyne (d) 16.95×10^{-5} dyne

VITEEE-2019

Ans. (a) : Radius of drop (r) = = 0.3mm = 0.03 cm
Terminal velocity (v) = 1m/s = 100 cm/sec
Viscosity of air $\eta = 8 \times 10^{-5}$ Poise
Viscous force, $F = 6\ \pi\eta rv$

$$F = 6 \times 3.14 \times (8 \times 10^{-5}) \times 0.03 \times 100$$
$$= 45.2 \times 10^{-4} \text{ dyne}$$

200. A particle moves in a straight line with a velocity v and moves under retardation equal to k times the distance described. What is the distance covered before it comes to rest?

(a) $v\sqrt{k}$ (b) $v/\sqrt{k}$
(c) $2v/\sqrt{k}$ (d) None of the above

SCRA-2012

Ans. (b) : $a = -v\dfrac{dv}{dx} = kx$

$$-v\frac{dv}{dx} = kx$$

$$\int_v^0 -v\,dv = \int_0^x kx\,dx$$

$$-\left[\frac{v^2}{2}\right]_v^0 = \left[\frac{kx^2}{2}\right]_0^x$$

$$+\frac{v^2}{2} = \frac{kx^2}{2}$$

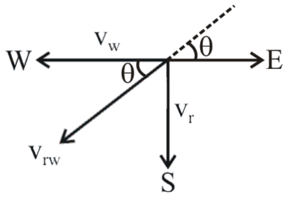
$$x^2 = \frac{v^2}{k} \Rightarrow x = \frac{v}{\sqrt{k}}$$

201. Rain is falling vertically with a speed of 12 ms^{-1}. A woman rides a bicycles with a speed of 12 ms^{-1} in east to west direction. What is the direction in which she should hold her umbrella ?

(a) 30^0, towards east (b) 45^0, towards east
(c) 30^0, towards west (d) 45^0, towards west

Karnataka CET-2020

Ans. (d) : Given,



Velocity of rain $v_r = 12\ ms^{-1}$
Velocity of woman $v_w = 12ms^{-1}$

$$v_{rw} = \sqrt{v_w^2 + v_r^2}$$
$$= \sqrt{(12)^2 + (12)^2} = 12\sqrt{2}\ ms^{-1}$$

$$\sin\theta = \frac{v_w}{v_{rw}} = \frac{12}{12\sqrt{2}}$$

$$\theta = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ \text{ west}$$

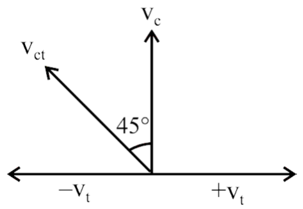
Hence, woman should hold her umbrella in 45° west direction.

202. A train is moving towards east and a car is along north, both with same speed. The observed direction of car to the passenger in the train is

(a) east-north direction
(b) west-north direction
(c) south-east direction
(d) none of these

BCECE-2018
J&K CET- 2004

Ans. (b) : Let, $\vec{v}_c$ = Velocity of car
$\vec{v}_t$ = Velocity of Train



Both speed is same

$$\tan\theta = \frac{-v}{v} \Rightarrow \tan\theta = -1 = \tan 135^\circ$$
$$\theta = 135^\circ$$

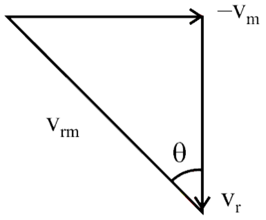
Hence, velocity of car w.r. to train is towards west-north direction.

203. A man rides a bicycle with a speed of 17.32 ms^{-1} East-West direction. If the rain falls vertically with a speed of 10 ms^{-1}, then the direction in which he must hold his umbrella is

(a) 30° with the vertical towards East
(b) 60° with the vertical towards West
(c) 30° with the vertical towards West
(d) 60° with the vertical towards East
(e) 0° with the vertical

Kerala CEE - 2016

Ans. (b) : Given that,
A man rides a bicycle with a speed of 17.32 ms^{-1} East-West direction
Speed of rain = 10 ms^{-1}



@apna_pdf

$$\tan\theta = \frac{v_m}{v_r} = \frac{17.32}{10} = 1.732$$

$$\tan\theta = 1.732$$

$$\tan\theta = \sqrt{3} \qquad \left[\because \sqrt{3} = 1.732\right]$$

$$\tan\theta = \tan 60°$$

$\theta = 60°$ with vertical towards west.

204. A train travels east towards Hubli at 80 km/h. A man on the train runs from the front of the train toward the rear of the train at 10 km/h with respect to train. As he runs, he carries a plate of fruit with him. He notices a giant spider on the plate and throws the plate away from him (toward the rear of the train) at 20 km/h with respect to him. Just after that instant, the startled spider jumps towards the man at 5 km/h with respect to plate. The instant after the spider jumps toward the man, how fast is the spider approaching Hubli?

(a) 45 km/h (b) 115 km/h

(c) 55 km/h (d) 95 km/h

UPSEE - 2018

Ans. (c) : Given that,

The velocity of train with respect to the earth,

$v_{T\to E} = 80$ km/h ....(i)

Velocity of the man w.r.t. the train,

$v_{M\to T} = -10$ km/h ....(ii)

Velocity of the plate w.r.t. the man,

$v_{P\to M} = -20$ km/h ....(iii)

Velocity of the spider w.r.t. the plate,

$v_{S\to P} = 5$ km/h ....(iv)

From eqn. (i), (ii), (iii), we get

∴ The velocity of the spider w.r.t. the earth,

$v_{S\to E} = v_{S\to P} + v_{P\to M} + v_{M\to T} + v_{T\to E}$

$= 5 - 20 - 10 + 80$

$= 5 - 30 + 80$

$= 55$ km/h (Towards Hubli)

205. A boat crosses a river from port A to port B, which are just on the opposite side. The speed of the water is v_w and that of boat is v_B relative to still water. Assume $v_B = 2v_w$. What is the time taken by the boat, if it has to cross the river directly on the AB line [D = width of the river]

(a) $\frac{2D}{V_B\sqrt{3}}$ (b) $\frac{\sqrt{3}D}{2V_B}$

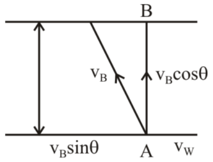
(c) $\frac{D}{V_B\sqrt{2}}$ (d) $\frac{D\sqrt{2}}{V_B}$

BITSAT-2019

Ans. (a) : Given that,

Also, $v_B = 2v_w \quad \therefore \frac{v_W}{v_B} = \frac{1}{2}$ ...(i)

Time taken by boat $t = ?$



$v_B \sin\theta = v_w$ ......(ii)

∴ from equation (i) and (ii)

$$v_B\sin\theta = \frac{v_B}{2} \Rightarrow \sin\theta = \frac{1}{2} \qquad \therefore \theta = 30°$$

We know, $t = \frac{D}{v_B\cos\theta} = \frac{D}{v_B\cos 30°}$

$$\therefore \quad = \frac{D}{v_B\left(\frac{\sqrt{3}}{2}\right)} \qquad \left(\cos 30° = \frac{\sqrt{3}}{2}\right)$$

$$\therefore \quad t = \frac{2D}{v_B\sqrt{3}}$$

206. A passenger in a open car travelling at 30 m/s throws a ball out over the bonnet. Relative to the car the initial velocity of the ball is 20 m/s at 60° to the horizontal. The angle of projection of the ball with respect to the horizontal road will be

(a) $\tan^{-1}\left(\frac{2}{3}\right)$ (b) $\tan^{-1}\left(\frac{\sqrt{3}}{4}\right)$

(c) $\tan^{-1}\left(\frac{4}{\sqrt{3}}\right)$ (d) $\tan^{-1}\left(\frac{3}{4}\right)$

BITSAT- 2011

Ans. (b) : Given that,

$v_c = 30$m/s

$v_{bc} = 20$m/s

and angle are = 60°

Now, velocity of ball with respect to car is

$$v_{bc} = 20\cos 60°\hat{i} + 20\sin 60°\hat{j}$$

$$v_{bc} = 20\times\frac{1}{2}\hat{i} + 20\times\frac{\sqrt{3}}{2}\hat{j}$$

$$\therefore v_{bc} = 10\hat{i} + 10\sqrt{3}\hat{j}$$

Now, we know that

$v_{bc} = v_b - v_c$

$$v_b = v_{bc} + v_c$$

$$v_b = 10\hat{i} + 10\sqrt{3}\hat{j} + 30\hat{i}$$

$$\therefore v_b = 40\hat{i} + 10\sqrt{3}\hat{j}$$

Now, angle of projection is :-

$$\tan\theta = \frac{10\sqrt{3}}{40}$$

$$\theta = \tan^{-1}\left(\frac{\sqrt{3}}{4}\right)$$

@apna_pdf

207. **A boy running on a horizontal road at 8 km/h finds the rain falling vertically. He increases his speed to 12 km/h and finds that the drops makes 30° with the vertical. The speed of rain with respect to the road is**

(a) $4\sqrt{7}\text{km/h}$ (b) $9\sqrt{7}\text{km/h}$

(c) $12\sqrt{7}\text{km/h}$ (d) $15\sqrt{7}\text{km/h}$

BITSAT- 2018

Ans. (a) : Given, $v_m = 8$ km/h

Let the velocity of rain $v_r = v_{rx}\hat{i} + v_{ry}\hat{j}$ ……(i)

Velocity of rain w.r.t. boy,

$v_{rm} = (v_{rx} - v_m)\hat{i} + v_{ry}\hat{j}$

Condition Ist –

$v_{rx} - v_m = 0$

$v_{rx} = 8\text{km/h}$

Condition IInd –

$$\tan 30° = \frac{v_{rx} - v_m}{v_{ry}} \Rightarrow \tan 30° = \frac{8-12}{v_{ry}}$$

$v_{ry} = -4\sqrt{3}\text{km/h}$

So from equation (i)

$v_r = 8\hat{i} - 4\sqrt{3}\hat{j}$

$$v_r = \sqrt{8^2 + \left(-4\sqrt{3}\right)^2}$$

$v_r = 4\sqrt{7}\text{km/h}$

208. **A man crosses a 320 m wide river perpendicular to the current in 4 min. If in still water he can swim with a speed 5/3 times that of the current, then the speed of the current, in mm^{-1} is**

(a) 30 (b) 40 (c) 50 (d) 60

Manipal UGET-2013

Ans. (d) : Given that,

Width of river (d) = 320 m

Time taken by the swimmer to cross the river = 4 min

Resultant velocity of the swimmer = $\frac{320}{4}$ = 80 m/min

Speed of the man (v) = $\frac{5}{3}u$

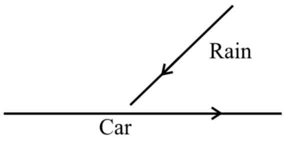
We know that,

$$t = \frac{d^2}{\sqrt{v^2 - u^2}} \Rightarrow 4 = \frac{320}{\sqrt{\left(\frac{5}{3}u\right)^2 - u^2}}$$

$$4 \times \frac{4}{3}u = 320$$

u = 60 meter/minute

209. **Rain is falling at an angle of 30^o from the vertical due to the wind with a speed of 40 m/s. A car is travelling horizontally in the direction opposite to the wind, at a speed of 40 m/s. At what angle from the vertical will it experience the rain falling from?**



(a) 30^o (b) 60^o

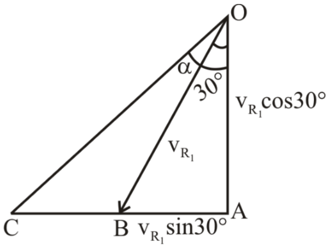
(c) 90^o (d) 120^o

TS-EAMCET-03.05.2019, Shift-1

Ans. (b) : Given that,

$v_{R_1} = 40$ m/s

$v_c = 40$ m/s



$$\tan(\alpha + 30°) = \frac{v_c + v_{R_1}\sin 30°}{\left(v_{R_1}\cos 30°\right)}$$

ΔOAB

$$\tan 30° = \frac{1}{\sqrt{3}}$$

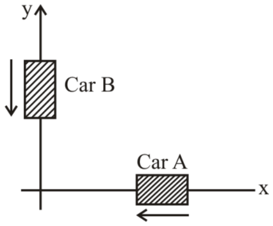
$$\tan(\alpha + 30°) = \frac{40 + 40\left(\frac{1}{2}\right)}{40\left(\frac{\sqrt{3}}{2}\right)}$$

$$\tan(\alpha + 30°) = \frac{40\left(\frac{3}{2}\right)}{40\left(\frac{\sqrt{3}}{2}\right)} = \frac{3}{\sqrt{3}}$$

$\tan(\alpha + 30°) = \tan 60°$

$\alpha + 30° = 60°$

210. **Two cars A and B are moving with speeds v_A = 120 km/h and v_B = 50 km/h respectively in the directions as indicated by the arrow in the figure below. What is the relative speed of the car B with respect to car A?**



(a) 70 km/h (b) 120 km/h

(c) 130 km/h (d) 170 km/h

TS-EAMCET-10.09.2020, Shift-2

Ans. (c) : Given that,

v_A = 120 km/h

v_B = 50 km/h

@apna_pdf

Relative speed of B with respect to A,

$$\text{Resultant} = \sqrt{v_A^2 + v_B^2}$$

$$= \sqrt{(120)^2 + (50)^2}$$

$$= \sqrt{16900} = 130 \text{ km/h}$$

211. A river 200 m wide is flowing at a rate of 3.0 m/s. A boat is sailing at a velocity of 15 m/s with respect to the water in a direction perpendicular to the river. How far from the point directly opposite to the starting point does the boat reach on the opposite bank?

(a) 25 m (b) 60 m

(c) 40 m (d) 50 m

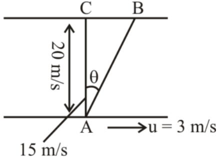
TS-EAMCET-11.09.2020, Shift-1

Ans. (c) :

Given that, distance between river bank = 200 m

Speed of Rivers water = 3 m/sec

Speed of sailing = 15 m/sec



$$\because \ \text{Time} = \frac{\text{Distance}}{\text{speed}} = \frac{200}{15} = 13.33 \text{ sec}$$

$$\text{Distance} = \text{velocity} \times \text{time}$$

$$= 3 \times 13.33 = 39.99 = 40 \text{ m}$$

212. Rain is falling vertically with a speed of 30 m/s. A man rides a bicycle with a speed of 10 m/s from East to West direction. At what the angle with the vertical, he sees the rain falling?

(a) $\tan^{-1}\left(\frac{1}{3}\right)$ towards West

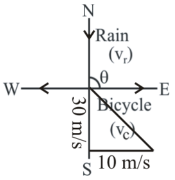
(b) $\tan^{-1}(3)$ towards West

(c) $\tan^{-1}\left(\frac{1}{3}\right)$ towards East

(d) $\tan^{-1}(3)$ towards East

TS-EAMCET-06.05.2019, Shift-1

Ans. (a) :



Let, v_r = Velocities of falling rain = 30 m/s

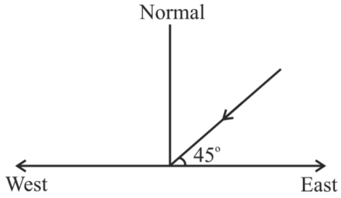
v_c = Velocities of the bicycle = 10 m/s. (East to west)

$$\because \quad \tan\theta = \frac{v_c}{v_r} = \frac{10}{30} = \frac{1}{3}$$

$$\theta = \tan^{-1}\left(\frac{1}{3}\right)$$

So, $\theta = \tan^{-1}\left(\frac{1}{3}\right)$ towards west.

213. A boy runs on a horizontal road with a speed of 4 m/s while it is raining. He sees that the rain is making an angle θ with the vertical while running from West to East. However, when he runs from East to West, the angle is α. The rain is pouring down at an angle 45° with the vertical normal and at a speed of 8 m/s as shown in the figure. The ratio $\frac{\tan\theta}{\tan\alpha}$ is



(a) $\left(1-\sqrt{2}\right)^2$ (b) $\left(1+\sqrt{2}\right)^2$

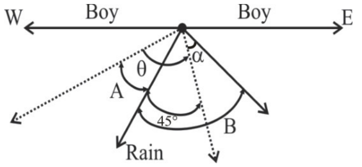
(c) $\left(1+\sqrt{2}\right)$ (d) $\left(\sqrt{2}-1\right)$

TS-EAMCET-03.05.2019, Shift-2

Ans. (b) : Given, v = 4 m/s

The boy is running from East to west, the angle is α and the rain is pouring down at an angle 45°.

Then, the relative motion between rain and boy.



$$\therefore \quad \tan A = \frac{4\sin 45^\circ}{8-4\cos 45^\circ}$$

$$\tan A = \frac{4\left(\frac{1}{\sqrt{2}}\right)}{8-4\left(\frac{1}{\sqrt{2}}\right)} = \frac{1}{\left(2\sqrt{2}-1\right)}$$

$$\tan B = \frac{4\sin(90^\circ+45^\circ)}{8-4\cos(90^\circ+45^\circ)} = \frac{1}{\left(2\sqrt{2}+1\right)}$$

From above figure,

$$\because \ \tan\theta = \tan(A+45^\circ) = \frac{\tan A + \tan 45^\circ}{1-\tan A \times \tan 45^\circ}$$

$$= \frac{\frac{1}{2\sqrt{2}-1}+1}{1-\frac{1}{2\sqrt{2}-1}\times 1} = \frac{\frac{1+2\sqrt{2}-1}{2\sqrt{2}-1}}{\frac{2\sqrt{2}-1-1}{2\sqrt{2}-1}} = \frac{\sqrt{2}}{\sqrt{2}-1}$$

and similarly

$$\because \ \tan\alpha = \tan(B-45^\circ) = \frac{\tan B - \tan 45^\circ}{1+\tan B \tan 45^\circ}$$

$$= \frac{\frac{1}{2\sqrt{2}+1}-1}{1+\frac{1}{2\sqrt{2}+1}\times 1} = \frac{\frac{-2\sqrt{2}+1-1}{2\sqrt{2}+1}}{\frac{2\sqrt{2}+1+1}{2\sqrt{2}+2}} = \frac{-2\sqrt{2}}{2\sqrt{2}+2}$$

@apna_pdf

$$=\frac{-\sqrt{2}}{\sqrt{2}+1}$$

Hence, $$\frac{\tan\theta}{\tan\alpha}=\frac{\frac{\sqrt{2}}{\sqrt{2}-1}}{\frac{-\sqrt{2}}{\sqrt{2}+1}}=\frac{\sqrt{2}}{\sqrt{2}-1}\times\frac{\sqrt{2}+1}{-\sqrt{2}}$$

$$=\frac{-(\sqrt{2}+1)}{(\sqrt{2}-1)}\times\frac{(\sqrt{2}+1)}{(\sqrt{2}+1)}=\frac{-(\sqrt{2}+1)^2}{2-1}$$

$$=-(1+\sqrt{2})^2 \square (1+\sqrt{2})^2$$

214. Assertion: The magnitude of velocity of two boats relative to river is same. Both boats start simultaneously from same point on the bank may reach opposite bank simultaneously moving along different paths.

Reason: For boats to cross the river in same time. The component of their velocity relative to river in direction normal to flow should be same.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

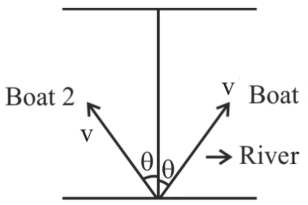
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (a) :



From the above figure, we say that it component of velocities of boat relative to river in direction normal to flow same, the both boats reach other bank simultaneously.

215. A train of 150 m length is going towards North direction at a speed of 10ms^{-1}. A parrot files at a speed of 5ms^{-1} towards South direction parallel to the railway track. The time taken by the parrot to cross the train is equal to–

(a) 12 s (b) 8 s

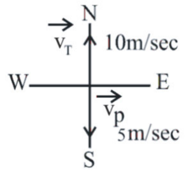
(c) 15 s (d) 10 s

BCECE-2017

Ans. (d) : Given that, length of train = 150 m

Speed of train = 10 m/sec (North direction)

Speed of parrot = 5 m/sec (South direction)



Relative velocity of parrot with respect to train

$$v = v_T + v_p$$

$$v = 10 + 5 = 15 \text{ m/sec}$$

As we know that

$$\text{Speed} = \text{distance} \times \text{time}$$

$$15 = 150 \times \text{time}$$

$$\text{Time} = \frac{150}{15} = 10\text{sec}$$

216. What will be the minimum speed of the roller - coaster so that the passenger at the top, when becomes upside down, do not fall out? Consider the acceleration due to gravity as 10 m/s^2, and the radius of curvature of the roller coaster is 10 m.

(a) 20 m/s (b) 10 m/s

(c) 15 m/s (d) 25 m/s

TS EAMCET 04.08.2021, Shift-II

Ans. (b) : Given that, acceleration due to gravity (g) = 10 m/sec

Radius of curvature of roller coaster = 10 m

$\because$ $F_c = ma_c$

$mg = ma_c$

$\boxed{g = a_c}$

$\because$ $a_c = \frac{v^2}{r}$

$v^2 = ra_c \Rightarrow v = \sqrt{ra_c}$

$v = \sqrt{10\times10} = \sqrt{100}$

$\boxed{v = 10 m/sec}$

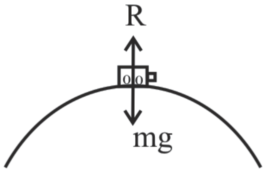
217. A car is moving with velocity v at the top of a semi-circular hill of radius 40 m such that the normal force on it is zero. Find the velocity (v) of the car.

(a) 15 ms^{-1} (b) 20 ms^{-1}

(c) 30 ms^{-1} (d) 40 ms^{-1}

TS EAMCET 06.08.2021, Shift-I

Ans. (b) : Equation of motion of car



$mg - R = \frac{mv^2}{r}$

Given, normal force R = 0

$mg = \frac{mv^2}{r}$

$v^2 = rg$

$v = \sqrt{gr} = \sqrt{40\times10} = \sqrt{400}$

$v = 20$ m/s

218. A particle moves in a circle of radius 25 cm at two revolutions per second. The acceleration of the particle in meter per second^2 is

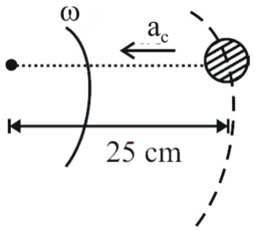
(a) π^2 (b) $8\pi^2$

(c) $4\pi^2$ (d) $2\pi^2$

AIIMS-2012

@apna_pdf

Ans. (c) : Given that, circle of radius = 25 cm



$$f = 2 \text{ rad/sec}$$

$$\omega = 2\pi f = 2\times 2\pi$$

$$\omega = 4\pi \text{ rad/sec}$$

$$a_c = \frac{v^2}{r} = \frac{(r\omega)^2}{r} = r\omega^2 = 25\times 10^{-2}\times (4\pi)^2$$

$$= 0.25 \times 16\pi^2$$

$$a_c = 4\pi^2 \text{ m/s}^2$$

219. A police jeep is chasing with velocity of 45 km/h, a thief in another jeep moving with velocity 153 km/h. Police fires a bullet with muzzle velocity of 180 m/s. The velocity with which it will strike the jeep of the thief, is

(a) 150 m/s
(b) 27 m/s
(c) 450 m/s
(d) 250 m/s

UP CPMT-2004
Manipal UGET-2013

Ans. (a) : Speed of thief's Jeep = 153 km/h

$$= 153\times\frac{5}{18}\text{ m/s}$$

$$= 42.5 \text{ m/s}$$

Effective speed of the bullet

= speed of bullet + speed of police jeep.

= 180 m/s + 45 km/h

$$= 180 \text{ m/s} + 45\times\frac{5}{18}\text{ m/s}$$

= 180 m/s + 12.5 m/s = 192.5 m/s

Velocity of bullet w.r.t thief's jeep = Effective speed of the bullet – speed of thief's jeep

= 192.5 – 42.5 = 150 m/s

220. A motor cyclist is riding North in still air at 36 km/h, the wind starts blowing westward with a velocity 18 km/h. The direction of apparent velocity is

(a) $\tan^{-1}\frac{1}{2}$ West of North

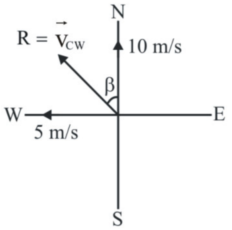
(b) $\tan^{-1}\frac{1}{2}$ North of West

(c) $\tan^{-1}\frac{1}{2}$ East of North

(d) $\tan^{-1}\frac{1}{2}$ North of East

UP CPMT-2012

Ans. (a) :



Velocity of cyclist in north (v_c)= 36 km/h

$$36\text{ km/h} = 36\times\frac{5}{18}\text{ m/s} = 10\text{ m/s}$$

Velocity of wind in west = v_w = 18 km/h

$$= 18\times\frac{5}{18}\text{ m/s} = 5\text{ m/s}$$

Direction of motion = tan β

$$\therefore \tan\beta = \frac{v_w}{v_c} = \frac{5}{10} = \frac{1}{2}$$

$$\beta = \tan^{-1}\left(\frac{1}{2}\right)\text{west of north}$$

221. A swimmer wants to cross a 200 m wide river which is flowing at a speed of 2 m/s. The velocity of the swimmer with respect to the river is 1 m/s. How far from the point directly opposite to the starting point does the swimmer reach the opposite bank?

(a) 200 m
(b) 400 m
(c) 600 m
(d) 800 m

TS EAMCET (Engg.)-2017

Ans. (b) : Given,

velocity of Man (v_{man}) = 1 m/s
velocity of river (v_{river}) = 2 m/s
width of river (w) = 200m

We know that,

$$\because \quad \frac{w}{v_{man}} = \frac{d}{v_{river}}$$

$$d = \frac{v_{river}\times w}{v_{man}} \Rightarrow d = \frac{2\times 200}{1}$$

$$\boxed{d = 400\text{m}}$$

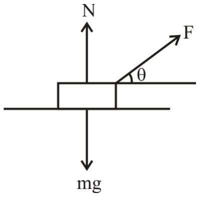
222. At time t = 0, a force F = αt, where t is time in seconds, applied to a body of mass 1 kg, resting on a smooth horizontal plane. If the direction of the force makes an angle of 45° with the horizontal, then the velocity of the body at the moment of its breaking off the plane is

(a) $\frac{100}{\alpha}$ m/s
(b) $\frac{50\sqrt{2}}{\alpha}$ m/s
(c) $\frac{50\alpha}{\sqrt{2}}$ m/s
(d) $\frac{50}{\alpha}$ m/s

TS EAMCET 20.07.2022, Shift-I

Ans. (b) : Given, t = 0, A Force F = αt is applied to small body of mass m resting on a smooth horizontal plane where α is constant.

@apna_pdf



The normal reaction will be zero where the body will leave the ground surface.

$\Rightarrow N = mg - \alpha t_0 \sin\theta$

$\Rightarrow mg - \alpha t_0 \sin\theta = 0$

$$t_0 = \frac{mg}{\alpha \sin\theta} \qquad \text{....(i)}$$

t_0 = time where the body leaves the ground. The force component on horizontal direction is

$\Rightarrow ma_x = \alpha t \cos\theta \qquad$ ....(ii)

$$\because \quad a_x = \frac{dv_x}{dt}$$

$$\therefore \quad m \times \frac{dv_x}{dt} = \alpha t \cos\theta$$

$m.dv_x = \alpha \cos\theta.\ tdt$

Integrating both side,

$$m\int_0^v dv_x = \alpha\cos\theta \int_0^{t_0} tdt$$

$$m.v = \alpha\cos\theta \cdot \left(\frac{t_0^2}{2}\right)$$

$$\Rightarrow \quad v = \frac{\alpha\cos\theta.t_0^2}{2m} \qquad \text{....(iii)}$$

Put $t_0 = \dfrac{mg}{\alpha\sin\theta}$ in equation (iii)

$$v = \frac{\alpha\cos\theta}{2m}\cdot\left(\frac{mg}{\alpha\sin\theta}\right)^2$$

$$v = \frac{\alpha\cos\theta}{2m}\cdot\frac{m^2g^2}{\alpha^2\sin^2\theta}$$

$$v = \frac{\alpha\cos\theta\times m^2g^2}{\alpha^2\sin^2\theta\ 2m}$$

$$v = \frac{mg^2\cos\theta}{2\alpha\sin^2\theta}$$

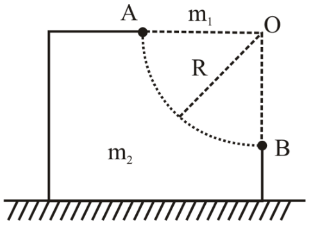
$$\boxed{v = \frac{mg^2}{2\alpha\sin\theta.\tan\theta}}$$

Given, m = 1 kg, $\theta = 45^\circ$

$$v = \frac{1\times(10)^2}{2\alpha.\sin45^\circ\tan45^\circ} \qquad \{\because\ g = 10\,m/s^2\}$$

$$v = \frac{100}{2\alpha.\frac{1}{\sqrt{2}}\times1} \Rightarrow v = \frac{50\sqrt{2}}{\alpha}\ m/s$$

223. A marble of mass m_1 slides down an arc of circular track from rest as shown in the figure. Assume the track is frictionless. If the block having the track has a mass m_2 and can also slide frictionless on the table the velocity of the particle when it exits the track at B is



(a) $\sqrt{gR}$ (b) $\sqrt{gR\left(1+\frac{m_1}{m_2}\right)}$

(c) $\sqrt{2gR(m_1+m_2)}$ (d) $\sqrt{\frac{2gRm_2}{(m_1+m_2)}}$

TS EAMCET 03.05.2018, Shift-I

Ans. (d) : From question

We have

$m_1v = m_2u$

$$u = \frac{m_1v}{m_2}$$

By conservation of Energy

$$\therefore \frac{1}{2}m_1v^2 + \frac{1}{2}m_2u^2 = m_1gR$$

$$\frac{1}{2}m_1v^2 + \frac{1}{2}m_2\left(\frac{m_1v}{m_2}\right)^2 = m_1gR$$

$$\frac{1}{2}m_1v^2 + \frac{1}{2}m_2\times\frac{m_1^2v^2}{m_2^2} = m_1gR$$

$$\frac{1}{2}m_1v^2 + \frac{1}{2}\frac{m_1^2v^2}{m_2} = m_1gR$$

$$\frac{1}{2}v^2 + \frac{1}{2}\frac{m_1}{m_2}v^2 = gR$$

$$\frac{1}{2}v^2\left(1+\frac{m_1}{m_2}\right) = gR$$

$$\frac{1}{2}v^2\left(\frac{m_2+m_1}{m_2}\right) = gR$$

$$v^2 = \frac{2gRm_2}{(m_1+m_2)}$$

$$v = \sqrt{\frac{2gRm_2}{(m_1+m_2)}}$$

224. A man can swim with a speed of 4 kmh^{-1} in still water. How long does he take to cross a river 1 km wide, if the river flows steadily 3 kmh^{-1} and he makes his strokes normal to the river current.

(a) 30 minutes (b) 25 minutes

(c) 20 minutes (d) 15 minutes

TS EAMCET 06.08.2021, Shift-II

@apna_pdf

Ans. (d) : Time to cross the river

$$t=\frac{\text{Width of river}}{\text{Speed of man}}=\frac{1\,\text{km}}{4\,\text{kmh}^{-1}}$$

$$=\frac{1}{4}\text{hr}=\frac{1}{4}\times 60\,\text{min} \qquad \{\because 1\text{ hr} = 60\text{ min}\}$$

$$\boxed{t=15\,\text{min}}$$

225. A bus is moving on a straight road towards North with a uniform speed of 50 km/h. If the speed remains unchanged after turning through 90^o, the increase in the velocity of bus in the turning process is

(a) 70.7 km/h along South-West direction
(b) zero
(c) 50 km/h along West
(d) 70.7 km/h along North-West direction

[AIPMT 1989]

Ans. (a) : Let $\vec{v}_1 = 50\hat{j}$ kmph

and $\vec{v}_2 = -50\hat{i}$ kmph

Let North = Y axis

West = X-axis (when the car turns left)

Change in velocity is

$\vec{v}_2 - \vec{v}_1 = (-50\hat{i} - 50\hat{j})$kmph

∴ Magnitude of change in velocity is =

$|\vec{V}_2 - \vec{V}_1| = \sqrt{50^2 + 50^2}$

$= 50\sqrt{2} = 50 \times 1.414$

= 70.7 km/h along south -west direction

226. The speed of a boat is 5 km/h in still water. It crosses a river of width 1.0 km along the shortest possible path in 15min. The velocity of the river water is (in km/h)

(a) 5
(b) 1
(c) 3
(d) 4

[AIPMT 1998]

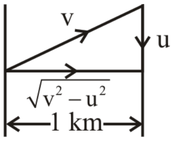
Ans. (c) : Given, speed of a boat (v) = 5 km/h

Let speed of river = u

Shortest possible path = 1km = s

Time taken = 15 min = 0.25 hr = t

We know that,



$$\frac{\text{distance}}{\text{time}} = \text{speed}$$

$$\frac{s}{t} = \sqrt{v^2-u^2}$$

$$\frac{1}{0.25} = \sqrt{25-u^2}$$

$$\frac{100}{25} = \sqrt{25-u^2}$$

$$4 = \sqrt{25-u^2}$$

$$16 = \left(\sqrt{25-u^2}\right)^2$$

$16 = 25 - u^2$

$u^2 = 9$

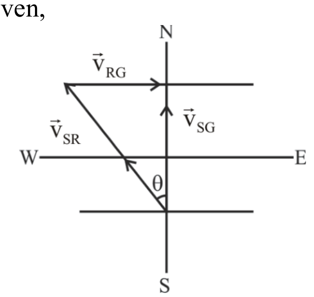
u = 3 km/h

227. The speed of a swimmer in still water is 20 m/s. The speed of river water is 10m/s and is flowing due east. If he is standing on the south bank and wishes to cross the river along the shortest path the angle at which he should make his strokes w.r.t. north is given by

(a) 0^o
(b) 60^o west
(c) 45^o west
(d) 30^o west

[NEET (National) 2019]

Ans. (d) : Given,



Speed of river flow, $\vec{v}_{RG} = 10\text{m/s}$

Speed of swimmer w.r.t. river,

$\vec{v}_{SR} = 20\text{m/s}$

∴ $\vec{v}_{SG} = \vec{v}_{SR} + \vec{v}_{RG}$

Then, $\sin\theta = \frac{|\vec{v}_{RG}|}{|\vec{v}_{SR}|}$

$$\sin\theta = \frac{10}{20}$$

$$\sin\theta = \frac{1}{2}$$

$$\theta = \sin^{-1}\frac{1}{2}$$

$\theta = 30^o$ West

228. A ship A is moving Westwards with a speed of 10 km h^{-1} and a ship B 100 km South of A, is moving Northwards with a speed of 10 kmh^{-1}. The time after which the distance between them becomes shortest is

(a) 0 h
(b) 5 h
(c) $10\sqrt{2}$ h
(d) $10\sqrt{2}$ h

[AIPMT 2015]

Ans. (b) : Given,

velocity of ship 'A', $\overrightarrow{v_A} = -10\hat{i}$ km/h

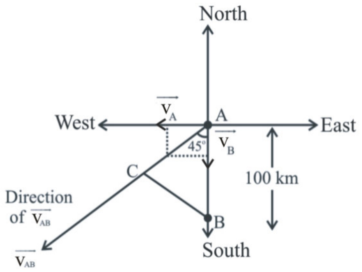
velocity of ship 'B', $\overrightarrow{v_B} = 10\hat{j}$ km/h

∴ $\overrightarrow{v_{AB}} = \overrightarrow{v_B} - \overrightarrow{v_A} = \left(10\hat{j} + 10\hat{i}\right)$km/h

$|\overrightarrow{v_{AB}}| = |\overrightarrow{v_B} - \overrightarrow{v_A}| = \sqrt{(10)^2 + (10)^2}$

$= 10\sqrt{2}$ km/h along AC

@apna_pdf



From figure, $AC = \frac{100}{\sqrt{2}} \text{km.} = 50\sqrt{2}$

So, $t = \frac{AC}{|\vec{v}_{AB}|}$

$$t = \frac{50\sqrt{2}}{10\sqrt{2}} = 5h$$

229. A metro train starts from rest and in 5 sec achieves 108 km/h. After that it moves with constant velocity and comes to rest after travelling 45 m with uniform retardation. If total distance travelled is 395 m, find total time of travelling.

(a) 12.2 s
(b) 15.3 s
(c) 9 s
(d) 17.2 s

JIPMER-2011

Ans. (d) : Given that, v = 108 km/h = 30 m/s, t = 5s

From the first equation of motion

$$v = u + at$$

$$30 = 0 + a \times 5 \qquad (\because u = 0)$$

$$a = 6 \text{ m/s}^2$$

Distance travelled by metro train in 5s

$$s_1 = \frac{1}{2}at^2 = \frac{1}{2} \times 6 \times (5)^2$$

$$s_1 = 75\text{m}$$

Distance travelled before coming to rest = 45m

From third equation of motion

$$(0)^2 = (30)^2 - 2a' \times 45$$

$$a' = \frac{30 \times 30}{2 \times 45}$$

$$a' = 10\text{m/s}^2$$

Time taken in travelling 45 m is

$$t_3 = 30/10$$

$$t_3 = 3 \text{ s}$$

Now, total distance = 395 m

$$75 + s' + 45 = 395 \text{ m}$$

i.e. $s' = 395 - (75 + 45)$

$$s' = 275\text{m}$$

$\therefore$ $t_2 = 275/30$

$$t_2 = 9.2\text{s}$$

Hence, total time taken in whole journey

$$= t_1 + t_2 + t_3 = 5 + 9.2 + 3 = 17.2 \text{ s}$$

230. A river is flowing from west to east with a speed of 5 m/min. A man can swim in still water with a velocity 10m/min. In which direction should the man swim so, as to take the shortest possible path to go to the south?

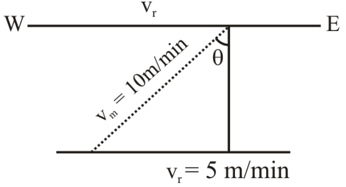
(a) 30° east of south
(b) 60° east of south
(c) 60° west of south
(d) 30° west of south

JIPMER-2005

Ans. (d) : Given,

Velocity of river flow (v_r) = 5m/min.

Velocity of man (v_m) = 10m/min



From, the figure, $\sin\theta = \frac{v_r}{v_m} = \frac{5}{10} = \frac{1}{2}$

$$\sin\theta = \frac{1}{2}$$

$$\theta = \sin^{-1}\frac{1}{2}$$

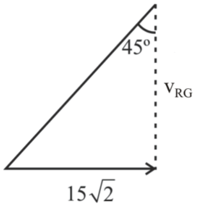
$\boxed{\theta = 30^\circ}$ west of south.

231. A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2}$ kmh^{-1}, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is

(a) 30 kmh^{-1}
(b) $\frac{25}{\sqrt{2}}$kmh^{-1}
(c) $\frac{30}{\sqrt{2}}$kmh^{-1}
(d) 25 kmh^{-1}

JEE Main-27.06.2022, Shift-I

Ans. (c) :



From figure,

$$\tan\theta = \frac{v_{RG}}{15\sqrt{2}}$$

$$v_{RG} = 15\sqrt{2}\tan 45^\circ = 15\sqrt{2} \times 1 = 15\sqrt{2}$$

$\therefore$ $15\sqrt{2} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{15 \times 2}{\sqrt{2}} = \frac{30}{\sqrt{2}}$ km/h

232. A particle is moving Eastwards with a velocity of 5 ms^{-1}. In 10 s, the velocity changes to 5 ms^{-1} Northwards. The average acceleration in this time is

@apna_pdf

(a) $\frac{1}{\sqrt{2}}\text{ms}^{-2}$ towards North-East

(b) $\frac{1}{2}\text{ms}^{-2}$ towards North

(c) zero

(d) $\frac{1}{\sqrt{2}}\text{ms}^{-2}$ towards North-West

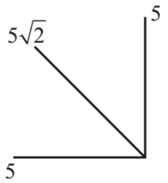
AIEEE 2005

Ans. (d) : As we know that,

Avg. acceleration = $\frac{\text{Change in velocity}}{t} = \frac{\Delta v}{t}$

Find the change in velocity Δv

$$\Delta v = v_f - v_i \qquad \because v_f = 5\hat{j}$$
$$v_i = 5\hat{i}$$
$$= 5\hat{j} - (5\hat{i}) = 5\hat{j} - 5\hat{i}$$



$|\Delta v| = \sqrt{5^2+5^2} = 5\sqrt{2}$

Avg. acceleration $= \frac{\Delta v}{t} = \frac{5\sqrt{2}}{10} = \frac{\sqrt{2}}{2} = \frac{\sqrt{2}}{\sqrt{2}\times\sqrt{2}} = \frac{1}{\sqrt{2}}$

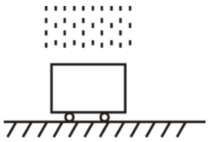
The average acceleration in this time is $\frac{1}{\sqrt{2}}\text{m/s}^2$ towards North-West direction.

233. When a car is at rest, its driver sees rain drops falling on it vertically. When driving the car with speed v, he sees that rain drops are coming at an angle 60° from the horizontal. On further increasing the speed of the car to (1+β)v, this angle changes to 45°. The value of β is close to

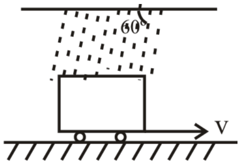
(a) 0.50
(b) 0.41
(c) 0.37
(d) 0.73

JEE Main-06.09.2020, Shift-II

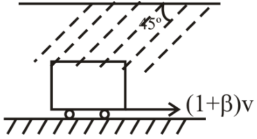
Ans. (d) : Given,



When car is at rest position its driver sees rain drops falling on it vertically.



When car is moving with speed of v then the rain drops are coming at angle 60° from the horizontal.



On further increasing the speed of car to (1+β)v, this angle changes to 45°

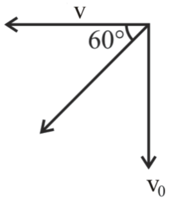
In the case Ist

$\overrightarrow{v_{RG}} = v_0(-\hat{j})$

In the case IInd

$\overrightarrow{v_{RC}} = \overrightarrow{v_{RG}} - \overrightarrow{v_{CG}} = v_0(-\hat{j}) - v\hat{i}$

$\overrightarrow{v_{RC}} = -v_0\hat{j} - v\hat{i}$



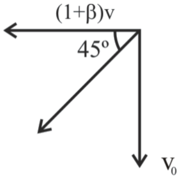
$\tan 60^\circ = \left(\frac{v_0}{v}\right)$

$\sqrt{3} = \frac{v_0}{v}$

$v_0 = \sqrt{3}v$

$\vec{v}_{RC} = \vec{v}_{RG} - \vec{v}_{CG}$

$= -v_0(\hat{j}) - (1+\beta)v\hat{i}$



$\tan 45^\circ = \frac{v_0}{(1+\beta)v} = 1$

$v_0 = v(1+\beta)$

$\sqrt{3}v = v(1+\beta)$

$\sqrt{3} - 1 = \beta$

$\beta = \sqrt{3} - 1 = (1.732 - 1) = 0.732$

$\beta = 0.732$

234. A particle is moving along the x-axis with its coordinate as a function of time given by x(t) =10+8t −3t^2. Another particle is moving along the y-axis with its coordinate as a function of time given by y(t) = 5 − 8t^3. At t =1s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v (in m/s) is ……… .

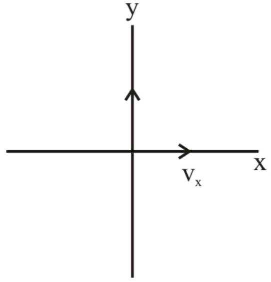
JEE Main-08.01.2020, Shift-I

@apna_pdf

Ans. (580m/s) Given,

$x(t) = 10 + 8t - 3t^2$

$y(t) = 5 - 8t^3$



(i) $x(t) = 10 + 8t - 3t^2$

$$\vec{v}_x = \frac{dx(t)}{dt} = 8 - 6t$$

$$\vec{v}_x = 8 - 6 \times 1\,m/s \qquad \{\because t = 1 \text{ sec}\}$$

$$= 8 - 6 = 2 \text{ m/s}$$

$$\vec{v}_x = 2\hat{i}\,m/s$$

(ii) $y(t) = 5 - 8t^3$

$$\vec{v}_y = \frac{dy(t)}{dt} = 0 - 8 \times 3t^2$$

$$= -8 \times 3t^2 \qquad \{\because t = 1 \text{ sec}\}$$

$$= -8 \times 3 \times 1^2 = -24\hat{j}\,ms^{-1}$$

$$\vec{v}_{yx} = \vec{v}_x - \vec{v}_y$$

$$\vec{v}_{yx} = 2\hat{i} - (-24)\hat{j}$$

$$\vec{v}_{yx} = 2\hat{i} + 24\hat{j}$$

The magnitude of $\vec{V}_{yx}$

$$\left|\vec{v}_{yx}\right| = \sqrt{(24)^2 + (2)^2} = \sqrt{v}\,(\text{given})$$

$$\sqrt{v} = \sqrt{576 + 4} = \sqrt{580}$$

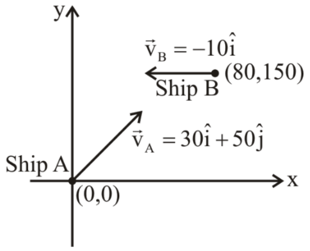
$$v = 580 \text{ m/s}$$

235. Ship A is sailing towards north-east with velocity $v = 30\hat{i} + 50\hat{j}$ km/h, where $\hat{i}$ points east and $\hat{j}$ north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards west at 10 km/h. A will be at minimum distance from B in

(a) 4.2 h (b) 2.6 h
(c) 3.2 h (d) 2.2 h

JEE Main-08.04.2019, Shift-I

Ans. (b) :



$$\vec{v}_A = 30\hat{i} + 50\hat{j}$$

$$\vec{v}_B = -10\hat{i}$$

$$\vec{r}_A = 0\hat{i} + 0\hat{j}$$

$$\vec{r}_B = 80\hat{i} + 150\hat{j}$$

$$\vec{v}_{BA} = \vec{v}_A - \vec{v}_B$$

$$= 30\hat{i} + 50\hat{j} - (-10\hat{i})$$

$$= 30\hat{i} + 50\hat{j} + 10\hat{i} = 40\hat{i} + 50\hat{j}$$

$$\vec{r}_{BA} = \vec{r}_A - \vec{r}_B = (0\hat{i} + 0\hat{j}) - (80\hat{i} + 150\hat{j})$$

$$= -80\hat{i} - 150\hat{j}$$

Time after which the distance will be minimum

$$t = -\frac{\vec{r}_{BA} \cdot \vec{v}_{BA}}{|\vec{v}_{BA}|^2}$$

$$t = -\frac{[-80\hat{i} - 150\hat{j}][40\hat{i} + 50\hat{j}]}{\left(\sqrt{1600 + 2500}\right)^2}$$

$$= \frac{3200 + 7500}{4100}\text{hr} = \frac{10700}{4100} = 2.609$$

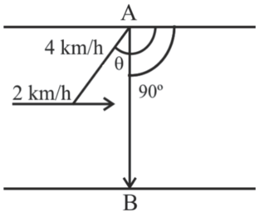
t = 2.60 hr

236. The stream of a river is flowing with a speed of 2 km/h. A swimmer can swim at a speed of 4 km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight ?

(a) 60° (b) 120°
(c) 90° (d) 150°

JEE Main-09.04.2019, Shift-I

Ans. (b) :



$$\sin\theta = \frac{v_r}{v_s} = \frac{2}{4}$$

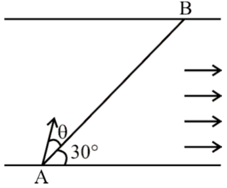
$$\sin\theta = \frac{1}{2}$$

$$\theta = 30^\circ$$

Angle with flow direction = 90° + θ°

= 90° + 30° = 120°

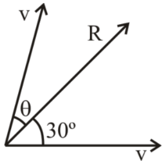
237. A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle θ with the line AB should be ……°, so that the swimmer reaches point B



JEE Main-27.07.2021, Shift-II

@apna_pdf

Ans. (30°)



Both velocity vectors are of same magnitude therefore resultant would pass exactly midway through them

$\theta = 30^\circ$

238. Three particles P, Q and R are moving along the vectors $A = \hat{i} + \hat{j}, B = \hat{j} + \hat{k}$ and $C = -\hat{i} + \hat{j}$, respectively. They strike on a point and start to move in different directions. Now, particle P is moving normal to the plane which contain vectors A and B. Similarly, particle Q is moving normal to the plane which contain vectors A and C. The angle between the direction of motion of P and Q is $\cos^{-1}\left(\frac{1}{\sqrt{x}}\right)$.

Then, the value of x is ....

JEE Main-22.07.2021, Shift-II

Ans :(3) Given, $\theta = \cos^{-1}\left(\frac{1}{\sqrt{x}}\right)$ ...(i)

Direction of P

$$\hat{v}_1 = \frac{\vec{A} \times \vec{B}}{|\vec{A} \times \vec{B}|} = \frac{(\hat{i}+\hat{j}) \times (\hat{j}+\hat{k})}{|(\hat{i}+\hat{j}) \times (\hat{j}+\hat{k})|} = \frac{\hat{i}-\hat{j}+\hat{k}}{\sqrt{3}}$$

Direction of P

$$\hat{v}_2 = \frac{\vec{A} \times \vec{C}}{|\vec{A} \times \vec{C}|} = \frac{(\hat{i}+\hat{j}) \times (-\hat{i}+\hat{j})}{|(\hat{i}+\hat{j}) \times (-\hat{i}+\hat{j})|} = \frac{2\hat{k}}{2} = \hat{k}$$

Angle between $\hat{v}_1$ and $\hat{v}_2$

$$\cos\theta = \frac{\hat{v}_1 . \hat{v}_2}{|\hat{v}_1||\hat{v}_2|}$$

$$= \frac{\left(\frac{\hat{i}-\hat{j}+\hat{k}}{\sqrt{3}}\right) \cdot \hat{k}}{\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{-1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2} \times \sqrt{1^2}} = \frac{1/\sqrt{3}}{(1)(1)} = \frac{1}{\sqrt{3}}$$

$$\cos\theta = \frac{1}{\sqrt{3}}$$

$$\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right) \quad \text{...(ii)}$$

Comparing equation (i) & (ii)

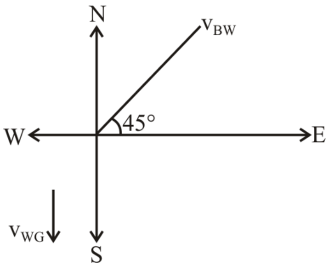
$x = 3$

239. A butterfly is flying with a velocity $4\sqrt{2}$m/s in North-East direction. Wind is slowly blowing at 1m/s from North to South. The resultant displacement of the butterfly in 3 s is

(a) 3m
(b) 20m
(c) $12\sqrt{2}$ m
(d) 15m

JEE Main-20.07.2021, Shift-I

Ans. (d) :



$\vec{v}_{BW}$ = velocity of butterfly in the frame of wind

$\vec{v}_{WG}$ = velocity of wind in the frame of ground

$$\vec{v}_{BW} = \vec{v}_{BG} - \vec{v}_{WG}$$

$$\vec{v}_{BG} = \vec{v}_{BW} + \vec{v}_{WG}$$

$$\therefore \quad \vec{v}_{BG} = \sqrt{(4\sqrt{2})^2 + (1)^2 + 2(4\sqrt{2})(1)\cos(90^\circ + 45^\circ)}$$

$$\vec{v}_{BG} = \sqrt{32 + 1 + 2 \times 4\sqrt{2} \times \frac{-1}{\sqrt{2}}}$$

$$\vec{v}_{BG} = \sqrt{25} = 5 \text{ m/s}$$

So, displacement in 3 second.

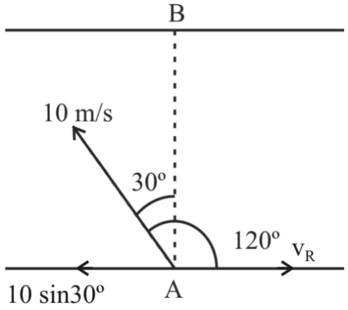
$d = \vec{v}_{BW} \times t$

$d = 5 \times 3 \Rightarrow d = 15$ m

240. A person is swimming with a speed of 10m/s at an angle of 120° with the flow and reaches to a point directly opposite on the other side of the river. The speed of the flow is x m/s. The value of x to the nearest integer is ....

JEE Main-18.03.2021, Shift-I

Ans. (5) Since, the person reaches directly opposite side of the river, its velocity along the river must be zero.



$10 \sin 30^\circ = v_R$

$10 \times \frac{1}{2} = v_R \Rightarrow v_R = 5$ m/s

241. A swimmer can swim with velocity of 12 km/h in still water. Water flowing in a river has velocity 6 km/h. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is ....° (in degree).

(Round off to the nearest integer)

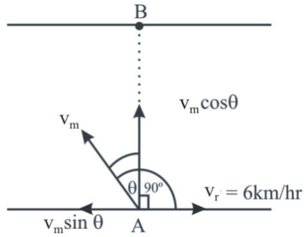
JEE Main-16.03.2021, Shift-II

@apna_pdf

Ans: (120) Given,

$v_m = 12$ km/hr

$v_r = 6$ km /hr



$v_m \sin\theta = v_r$

$$\sin\theta = \frac{v_r}{v_m} = \frac{6}{12}$$

$$\sin\theta = \frac{1}{2} = \sin 30^\circ \qquad \Rightarrow \theta = 30^\circ$$

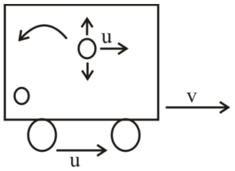
$\theta' = 90^\circ + 30^\circ \Rightarrow \theta' = 120^\circ$

242. A man sitting in a train in motion is facing the engine. He tosses a coin-up; the coin falls behind him. The train is:

(a) Moving forward with acceleration
(b) Moving forward with uniform speed
(c) Moving backward with deceleration
(d) Moving backward with uniform speed

AP EAMCET-25.09.2020, Shift-II

Ans. (a) :



If the train is accelerating then due to acceleration the velocity of train increases along the direction of motion and at this time when a coin is tossed it does not fall in the hand of the man it falls behind. As the train comes in acceleration motion in forward direction as soon as it is accelerated but at the same time the coin does not get accelerated and it falls behind.

243. A particle of mass 4 m explodes into three pieces of masses m, m and 2m. The equal masses move along X-axis and Y-axis with velocities 4 ms^{-1} and 6 ms^{-1} respectively. The magnitude of the velocity of the heavier mass is

(a) $\sqrt{17}$ ms^{-1}
(b) $2\sqrt{13}$ ms^{-1}
(c) $\sqrt{13}$ ms^{-1}
(d) $\frac{\sqrt{13}}{2}$ ms^{-1}

AP EAMCET -2009

Ans. (c) : Given,

$M = 4m, m_1 = m, m_2 = m, m_3 = 2m,$

$v_1 = 4$ m/s, $\qquad v_2 = 6$ m/s

$$\vec{p}_1 + \vec{p}_2 + \vec{p}_3 = 0$$

$$\vec{p}_3 = \left|\vec{p}_1 + \vec{p}_2\right|$$

$$p_3 = \sqrt{p_1^2 + p_2^2 + 2p_1p_2\cos\theta}$$

p_1 & p_2 are perpendicular to each other

$$p_3 = \sqrt{p_1^2 + p_2^2}$$

$$p_3 = \sqrt{(m_1v_1)^2 + (m_2v_2)^2}$$

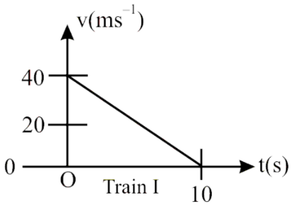
$$2mv_3 = \sqrt{(4m)^2 + (6m)^2}$$

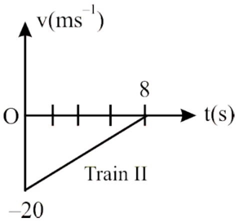
$$2mv_3 = \sqrt{52m^2}$$

$$2mv_3 = m\sqrt{52}$$

$$v_3 = \sqrt{13}\ \text{ms}^{-1}$$

244. Two trains, which are moving along different tracks in opposite directions, are put on the same track by mistake. On noticing the mistake, when the trains are 300 m apart the drivers start slowing down the trains. The graphs given below show decrease in their velocities as function of time. The separation between the trains when both have stopped is





(a) 120 m
(b) 20 m
(c) 60 m
(d) 280 m

AP EAMCET -2016

Ans. (b) :

Train-I

$v_1 = 40$ ms^{-1}

According first law of motion (v = u + at)

$v_1 = u_1 + a_1t$

$0 = 40 + a_1(10)$

$$a_1 = \frac{-40}{10} = -4\ \text{ms}^{-2}$$

Train-II

$v_2 = u_2 + a_2t$

$0 = -20 + a_2(8)$

$$a_2 = \frac{20}{8} = \frac{5}{2}\text{ms}^{-2}$$

Train-I

According second law of motion ($v^2 = u^2 - 2as$)

$$v_1^2 = u_1^2 - 2a_1s_1$$

$$0 = u_1^2 - 2a_1s_1$$

$$s_1 = \frac{u_1^2}{2a_1} = \frac{(40)^2}{2\times4} = \frac{1600}{8} = 200\text{m}$$

Train-II

$$v_2^2 = u_2^2 - 2a_2s_2$$

$$0 = u_2^2 - 2a_2s_2$$

$$\frac{u_2^2}{2a_2} = s_2 \Rightarrow s_2 = \frac{400\times2}{10} = 80\text{m}$$

@apna_pdf

Total distance covered by both trains,

$s = s_1 + s_2$

$s = 200+80$

$s = 280$ m

$\therefore$ Remaining Distance = 300 – 280=20 m

245. When a bomb is released from an aeroplane. the path described by it as observed by the pilot is

(a) Straight line
(b) Projectile
(c) Depends on speed of aeroplane
(d) None

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (a) : When a bomb is released from an aeroplane. the path described by it as observed by the pilot is straight line.

246. A bat and an insect are flying with velocities $\vec{V}_{BG}$ and $\vec{V}_{IG}$ respectively with respect to ground (in unit vector $\hat{i}, \hat{j}$ rotation)

$\vec{V}_{BG} = 3.5\hat{i} + 9.2\hat{j}, \vec{V}_{IG} = -2.5\hat{i} + 1.8\hat{j}$

Calculate the velocity of the insect with respect to bat.

(a) $1.5\hat{i} + 11.0\hat{j}$
(b) $-6\hat{i} - 7.4\hat{j}$
(c) $+6\hat{i} - 11.0\hat{j}$
(d) $1.0\hat{i} + 7.4\hat{j}$

AMU-2007

Ans. (b) : Given,

$$\vec{V_{BG}} = 3.5\hat{i} + 9.2\hat{j}$$

$$\vec{V_{IG}} = -2.5\hat{i} + 1.8\hat{j}$$

The velocity of the insect with respect to bat.

$$\vec{V_{IB}} = \vec{V_{BG}} - \vec{V_{IG}}$$

$$= \left(-2.5\hat{i} + 1.8\hat{j}\right) - \left(3.5\hat{i} + 9.2\hat{j}\right)$$

$$= -2.5\hat{i} + 1.8\hat{j} - 3.5\hat{i} - 9.2\hat{j} \quad = -6.0\hat{i} - 7.4\hat{j}$$

247. An object falls from a bridge 45m above the water level in a river. If falls directly into a boat moving with constant speed. The boat was 18 m away from the point of impact. What is the speed of the boat (in m/s)?

(a) 6 (b) 9 (c) 12 (d) 15

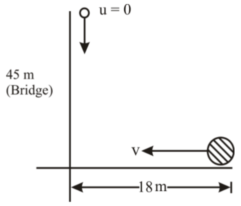
AMU-2007

Ans. (a) : Given h = 45m

We know that time taken by the object to fall through height (h) is

$$t = \sqrt{\frac{2h}{g}}$$

$$t = \sqrt{\frac{2 \times 45}{9.8}} = \sqrt{9.18} \qquad = 3.03\text{see} \approx 3\text{sec}$$

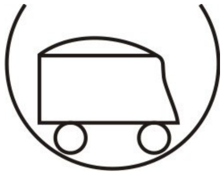


According to the question if v is the speed of boat then the distance travelled by boat in t = 3 sec is

$18 = v \times 3$ sec

$v = 6$ m/s

248. An automobile of mass m is crossing over a concave over bridge with speed v. If radius of bridge is R. The thrust on the bridge at the lowest point will be

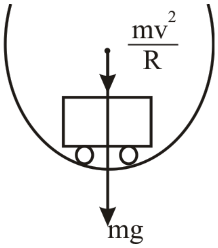


(a) $mg + \frac{mv^2}{R}$
(b) $mg - \frac{mv^2}{R}$
(c) mg
(d) $\frac{mv^2}{R}$

AMU-2001

Ans. (a) : We know that thrust on the bridge = weight + centripetal force

$$\text{Thrust} = mg + \frac{mv^2}{R}$$



249. A boat is moving from the east bank to the west bank on a south flowing river. If the speed of the boat is 4 km/h and that of the river is 3 km/h. If the width of the river is 2 km, the distance travelled by the boat is

(a) 5 km
(b) 4 km
(c) 3 km
(d) 2.5 km
(e) 2 km

Kerala CEE-2019

Ans. (d) : Given,

Speed of boat (v_b) = 4 km/hr

Speed of river (v_r) = 3 km/hr

width of river = 2 km

The magnitude of the resultant velocity

$$v_{res} = \sqrt{v_b^2 + v_r^2} = \sqrt{3^2 + 4^2}$$

$$v_{res} = 5\text{km/h}$$

Since horizontal component remain constant, so time taken in travelling 2km distance is

$$\boxed{t = \frac{2}{4} = 0.5\text{h}}$$

Distance travelled by the boat –

$d = v_{res} \times t = 5 \times 0.5 = 2.5$ km

@apna_pdf

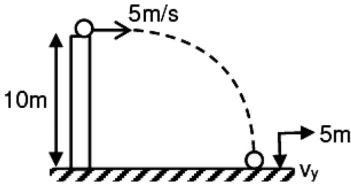
(d) Projectile Motion

250. A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 ms^{-1}. Neglecting the air resistance, the speed with which the stone hits the ground will be ________ms^{-1}.

(a) 15 (b) 20
(c) 30 (d) 25

JEE Main-01.02.2023, Shift-I

Ans. (a) : Given, h = 10 m, $v_x = 5$ m/s



$$v_y = \sqrt{2gh} = \sqrt{2\times10\times10} = 10\sqrt{2}\text{m/s}$$

$$v = \sqrt{{v_x}^2 + {v_y}^2} = \sqrt{5^2 + \left(10\sqrt{2}\right)^2}$$

$$= \sqrt{200+25} = 15\text{m/s}$$

8. Two objects are projected with same velocity 'u' however at different angles α and β with the horizontal. If $\alpha + \beta = 90°$, the ratio of horizontal range of the first object to the 2nd object will be :

(a) 1 : 2 (b) 4 : 1
(c) 2 : 1 (d) 1 :1

JEE Main-25.01.2023, Shift-II

Ans. (d) : Given, $\alpha + \beta = 90°$

$$\beta = 90° - \alpha$$

Range of projection angle (α),

$$R_1 = \frac{u^2 \sin 2\alpha}{g}$$

Range of projection angle (β),

$$R_2 = \frac{u^2 \sin 2\beta}{g} = \frac{u^2 \sin 2(90-\alpha)}{g} = \frac{u^2 \sin 2\alpha}{g}$$

Ratio of range R_1 and R_2,

$$\frac{R_1}{R_2} = \frac{\frac{u^2 \sin 2\alpha}{g}}{\frac{u^2 \sin 2\alpha}{g}} = \frac{1}{1}$$

$R_1 : R_2 = 1 : 1$

251. The maximum vertical height to which a man can throw a ball is 136 m. The maximum horizontal distance upto which he can throw the same ball is:

(a) 68 m (b) 136 m
(c) 192 m (d) 272 m

JEE Main-24.01.2023, Shift-I

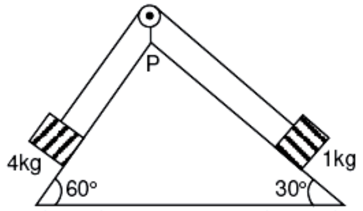
Ans. (d) : Given,
Maximum vertical height (H_{max}) = 136 m

$$\therefore \quad H_{max} = \frac{u^2}{2g} = 136\text{m}$$

Maximum horizontal distance,

$$R_{max} = \frac{u^2}{g} = 136\times2 = 272\text{m}$$

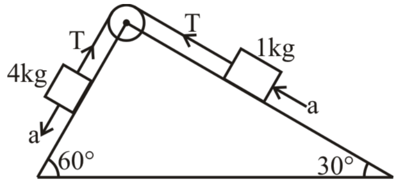
252. As per given figure, a weightless pulley P is attached on a double inclined frictionless surface. The tension in the string (massless) will be (if g = 10 m/s^2)



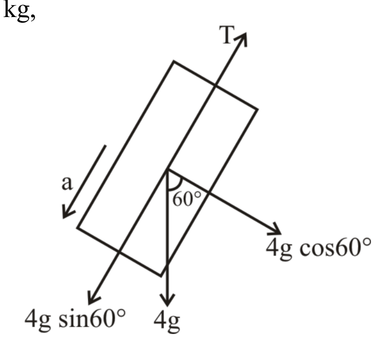
(a) $\left(4\sqrt{3}-1\right)$N (b) $4\left(\sqrt{3}-1\right)$N
(c) $\left(4\sqrt{3}+1\right)$N (d) $4\left(\sqrt{3}+1\right)$N

JEE Main-24.01.2023, Shift-I

Ans. (d) :



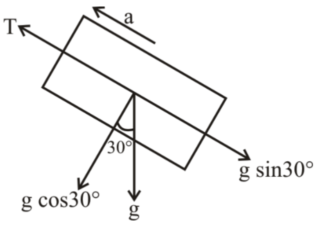
FBD of 4 kg,



$$4g \sin 60° - T = 4a$$

$$\frac{4g\sqrt{3}}{2} - T = 4a \qquad .....(i)$$

FBD of 1 kg,



$$T - g \sin 30° = a$$

$$T - \frac{g}{2} = a$$

$$4T - 2g = 4a \qquad .....(ii)$$

@apna_pdf

Solving equation (i) and (ii), we get–

$$\frac{4g\sqrt{3}}{2}-T=4T-2g$$

$$5T=g\left(2\sqrt{3}+2\right)$$

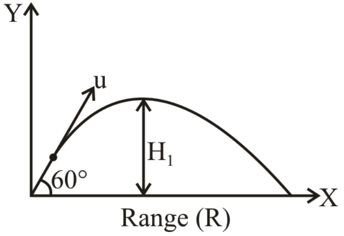
$$T=\frac{10}{5}\left(2\sqrt{3}+2\right)$$

$$=4\left(\sqrt{3}+1\right)N$$

253. Two bodies are projected from ground with same speeds 40 ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60° , with horizontal then sum of the maximum heights, attained by the two projectiles, is m. (given g = 10 ms^{-2})

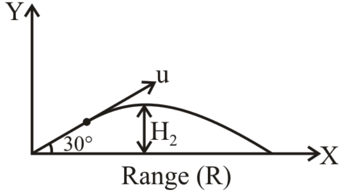
JEE Main-31.01.2023, Shift-II

Ans. (80) Given, $u = 40\ ms^{-1}$, $\theta = 60^o$, $g = 10\ ms^{-2}$



$$H_1=\frac{u^2\sin^2 60°}{2g}=\frac{3u^2}{8g}$$

For height of projection angle 30°,



$$H_2=\frac{u^2\sin^2(30^o)}{2g}$$

$$H_2=\frac{u^2}{8g}$$

Sum of the maximum heights of two projectiles,

$$\therefore \quad H_1+H_2=\frac{3u^2}{8g}+\frac{u^2}{8g}=\frac{4u^2}{8g}=\frac{4\times(40)^2}{8\times10}$$

$$=80\text{ m}$$

254. The initial speed of a projectile fired from ground is u. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}$u The time of flight of the projectile is:

(a) $\frac{2u}{g}$ (b) $\frac{u}{2g}$

(c) $\frac{u}{g}$ (d) $\frac{\sqrt{3}u}{g}$

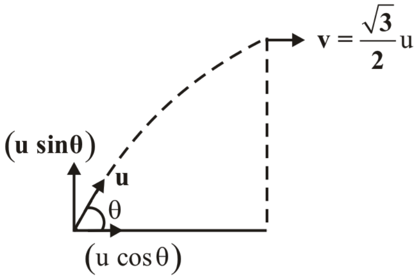
JEE Main-31.01.2023, Shift-I

Ans. (c) : Given, speed of projectile = $\frac{\sqrt{3}u}{2}$

We know that,

Time of flight $(T)=\frac{2u\sin\theta}{g}$

Where, u = Velocity of projection
g = Acceleration due to gravity



Velocity of particle at the highest point

$$u\cos\theta=\frac{\sqrt{3}}{2}u$$

$$\cos\theta=\frac{\sqrt{3}}{2}$$

$$\cos\theta=\cos30°$$

$$\theta=30^\circ$$

We know that, time of flight –

$$T=\frac{2u\sin\theta}{g}=\frac{2u\sin30°}{g}$$

$$T=\frac{u}{g}$$

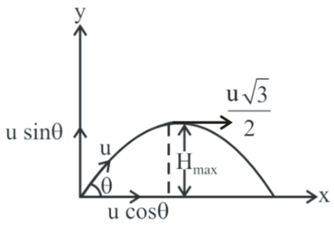
255. The speed of a projectile at its maximum height is $\frac{\sqrt{3}}{2}$ times its initial speed. If the range of the projectile is P times the maximum height attained by it, then P equals

(a) $\frac{4}{3}$ (b) $2\sqrt{3}$

(c) $4\sqrt{3}$ (d) $\frac{3}{4}$

AP EAMCET-1999

Ans. (c) :



According to question –

$$u\cos\theta=u\sqrt{3}/2$$

$$\cos\theta=\sqrt{3}/2$$

$$\theta=\cos^{-1}\left(\sqrt{3}/2\right)$$

$$\theta=30°$$

@apna_pdf

∵ $\text{Range (R)} = \dfrac{u^2 \sin 2\theta}{g}$

And maximum height $(H_{max}) = \dfrac{u^2 \sin^2 \theta}{2g}$

According to question –

$\text{Range (R)} = P \times H_{max}$ ….. (i)

$$\frac{u^2 \sin 2\theta}{g} = P.\ \frac{u^2 \sin^2 \theta}{2g}$$

$$2\sin\theta \cos\theta = \frac{P}{2}\sin^2\theta$$

$$\tan\theta = \frac{4}{P}$$

Putting the value of θ = 30°, we get–

$$\therefore \quad P = \frac{4}{\tan 30°}$$

$$P = 4\sqrt{3}$$

256. An object is projected with a velocity of 20 ms^{-1} making an angle of 45° with horizontal. The equation for the trajectory is $h = Ax - Bx^2$, where h is height, x is horizontal distance A and B are constants. The ratio A : B is ($g = 10\ ms^{-2}$)

(a) 1 : 5 (b) 5 : 1

(c) 1 : 40 (d) 40 : 1

AP EAMCET-2001

Ans. (d) : As we know that the equation of trajectory given as –

$$y = x\tan\theta - \frac{g x^2}{2u^2\cos^2\theta} \text{ …….. (i)}$$

According to question, equation of trajectory –

$$h = Ax - Bx^2 \text{ ………. (ii)}$$

Comparing equation (ii) with equation (i)

$$h = y,\ A = \tan\theta,\ B = \frac{g}{\left[2u^2\cos^2\theta\right]}$$

$$\frac{A}{B} = \frac{\tan\theta \times 2u^2 \times \cos^2\theta}{g} \quad \text{…..(iii)}$$

Given, $u = 20\,m/s,\ \theta = 45°,\ g = 10\,m/s^2$

Putting the value of these in equation (iii), we get–

$$\frac{A}{B} = \frac{2\times(20)^2\times(\cos 45°)^2\times\tan 45°}{10} = \frac{2\times 400\times\left(\frac{1}{\sqrt{2}}\right)^2\times 1}{10}$$

$$\frac{A}{B} = \frac{800\times\frac{1}{2}}{10} = \frac{800}{20} = \frac{40}{1}$$

A : B = 40 : 1

257. The horizontal and vertical displacements of a projectile at time t are x = 36 t and $y = 48t - 4.9t^2$ respectively. Initial velocity of the projectile in ms^{-1} is

(a) 15 (b) 30

(c) 45 (d) 60

AP EAMCET-2002

Ans. (d) : Given that, $x = 36t,\ y = 48t - 4.9t^2$

Horizontal velocity $(v_x) = \dfrac{dx}{dt} = \dfrac{d}{dt}36t = 36\,m/s$

Vertical velocity $(v_y) = \dfrac{dy}{dt} = \dfrac{d}{dt}(48t - 4.9t^2)$

$= 48 - 2 \times 4.9\,t$

At initial velocity, t = 0

$v_x = 36$ m/sec

$v_y = 48 - 2 \times 4.9 \times 0 = 48$ m/sec

Then velocity of projectile is,

$$\vec{v} = v_x\hat{i} + v_y\hat{j}$$

$$\vec{v} = 36\hat{i} + 48\hat{j}$$

$$|\vec{v}| = \sqrt{(36)^2 + (48)^2} = \sqrt{1296 + 2304} = \sqrt{3600}$$

= 60 m/sec

258. The horizontal and vertical displacements x and y of a projectile at a given time t are given by x = 6t metre and $y = 8t - 5t^2$ metre. The range of the projectile in metre is

(a) 9.6 (b) 10.6

(c) 19.2 (d) 38.4

AP EAMCET-2004

Ans. (a) : Given that-

$x = 6t,\ y = 8t - 5t^2$

Comparing from general formula

$$x = (u\cos\theta)t,\ y = (u\sin\theta)t - \frac{1}{2}gt^2$$

Then, $u\cos\theta = 6m/s,\ u\sin\theta = 8m/s,\ g = 10ms^{-2}$

We know that, $R = \dfrac{u^2 \sin 2\theta}{g}$

$$R = \frac{2(u\sin\theta).(u\cos\theta)}{g}$$

$$R = \frac{2\times 8\times 6}{10} = \frac{96}{10} = 9.6\ m$$

259. The equation of trajectory of a projectile is

$$\mathbf{y = 10x - \left(\frac{5}{9}\right)x^2}$$

If we assume $g = 10\ ms^{-2}$, the range of projectile (in metre) is

(a) 36 (b) 24

(c) 18 (d) 9

AP EAMCET-2005

Ans. (c) : Given that,

$$y = 10x - \frac{5}{9}x^2,\ g = 10ms^{-2}$$

We know that trajectory equation-

$$y = (\tan\theta)x - \left(\frac{g}{2u^2\cos^2\theta}\right)x^2$$

On comparing we get –

$$\tan\theta = 10,\ \frac{g}{2u^2\cos^2\theta} = \frac{5}{9}$$

@apna_pdf

$$\because \qquad R = \frac{u^2\sin 2\theta}{g} = \frac{2u^2\sin\theta.\cos\theta}{g}.$$

$$= \frac{2u^2\sin\theta.\cos\theta}{g}\times\frac{\cos\theta}{\cos\theta}$$

$$R = \frac{2.u^2\cos^2\theta\times\tan\theta}{g}$$

$$= \frac{\tan\theta}{\dfrac{g}{2u^2\cos^2\theta}} = \frac{10}{\dfrac{5}{9}} = \frac{90}{5} = 18\text{ m}$$

260. A body projected vertically upwards crosses a point twice in its journey at a height h just after t_1 and t_2 second. Maximum height reached by the body is

(a) $\frac{g}{4}(t_1+t_2)^2$
(b) $g\left(\frac{t_1+t_2}{4}\right)^2$
(c) $2g\left(\frac{t_1+t_2}{4}\right)^2$
(d) $\frac{g}{4}(t_1t_2)$

AP EAMCET-2005
VITEEE-2009

Ans. (c) : We know,

$$h = ut - \frac{1}{2}gt^2$$

At $t = t_1$ and t_2 second

Then, $h = ut_1 - \frac{1}{2}gt_1^2$ ……….(i)

$h = ut_2 - \frac{1}{2}gt_2^2$ ………(ii)

Equating (i) and (ii), we get–

$$ut_1 - \frac{1}{2}gt_1^2 = ut_2 - \frac{1}{2}gt_2^2$$

$$u(t_1 - t_2) = \frac{1}{2}g\left(t_1^2 - t_2^2\right)$$

$$u = \frac{(t_1+t_2)g}{2}$$

Maximum height $= \frac{u^2}{2g} = \frac{g^2(t_1+t_2)^2}{4\times 2g} = 2g\left(\frac{t_1+t_2}{4}\right)^2$

261. A body is projected from the earth at angle 30° with the horizontal with some initial velocity. If its range is 20 m, the maximum height reached by it is (in metre)

(a) $5\sqrt{3}$
(b) $\frac{5}{\sqrt{3}}$
(c) $\frac{10}{\sqrt{3}}$
(d) $10\sqrt{3}$

AP EAMCET-2006

Ans. (b) : Given that, $\theta = 30^o$, initial velocity = u, range (R) = 20 m, maximum height = H

We know that, $\tan\theta = \frac{4H}{R}$

$$H = \frac{1}{4}\times R\times\tan\theta$$

$$= \frac{1}{4}\times 20\times\tan 30^o = 5\times\frac{1}{\sqrt{3}}$$

$$H = \frac{5}{\sqrt{3}}\text{ m}$$

262. If a body is projected with an angle θ to the horizontal, then

(a) its velocity is always perpendicular to its acceleration
(b) its velocity becomes zero at its maximum height
(c) its velocity makes zero angle with the horizontal at its maximum height
(d) the body just before hitting the ground, the direction of velocity coincides with the acceleration

AP EAMCET-2008

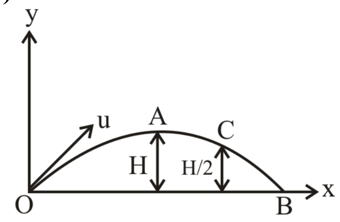
Ans. (c) : As we know that, in projectile motion a body at highest point has velocity = u cosθ in the horizontal direction which makes zero angle with the horizontal at its maximum height.

263. A ball thrown vertically up to reach its maximum height in t second. The total time from the time of projection to reach a point at half of its maximum height while returning (in second) is

(a) $\sqrt{2}t$
(b) $\left(1+\frac{1}{\sqrt{2}}\right)t$
(c) $\frac{3t}{2}$
(d) $\frac{t}{\sqrt{2}}$

AP EAMCET-2008
BITSAT-2008

Ans. (b) :



At maximum height final velocity is zero.

So,

Initial velocity $(v_0) = \sqrt{2gH}$ ………..(i)

And, $t = \frac{v_0}{g}$ …………(ii)

$t = \sqrt{\frac{2H}{g}}$ …………(iii)

Applying the relation for the motion from the point A and C

$$v^2 = u^2 + 2as$$

$$v_C^2 = v_A^2 + 2as$$

@apna_pdf

$$v_C^2 = 0 + 2g\left(\frac{H}{2}\right)$$

$$v_C = \sqrt{gH} \text{ ....(iv)}$$

For motion A to C

$$v_C = u_A + at_1$$

$$v_C = gt_1 \text{ ....(v)}$$

$$\sqrt{gH} = gt_1 \qquad \text{[From (iv)]}$$

$$t_1 = \sqrt{\frac{H}{g}} \text{ ....(vi)}$$

Comparing equation (iii) and (vi)

$$t_1 = \frac{t}{\sqrt{2}}$$

So, the time taken to reach half of the maximum height while returning is equal to

$$t_2 = t + t_1$$

$$t_2 = t + \frac{t}{\sqrt{2}}$$

$$t_2 = \left(1 + \frac{1}{\sqrt{2}}\right)t$$

264. For an object thrown at 45° to horizontal, the maximum height (H) and horizontal range (R) are related as

(a) R = 16 H
(b) R = 8 H
(c) R = 4 H
(d) R = 2 H

DCE-2009, 2007
JCECE-2004

Ans. (c) : Given, $\theta = 45^o$

$$\text{Maximum height of projectile } (H_{max}) = \frac{u^2 \sin^2\theta}{2g}$$

$$H_{max} = \frac{u^2 \sin^2 45^o}{2g} \text{.......(i)}$$

$$\text{Range of projectile } (R) = \frac{u^2 \sin 2\theta}{g}$$

$$R = \frac{u^2 \sin(2\times 45^o)}{g}$$

$$R = \frac{u^2 \sin 90^o}{g} \text{ ....(ii)}$$

Dividing Equation (i) by Equation (ii), we get–

$$\frac{H_{max}}{R} = \frac{u^2 \sin^2 45^o \times g}{2g \times u^2 \sin 90^o} = \frac{1}{2} \times \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{4}$$

So, $R = 4\,H_{max}$

265. Two objects are projected at an angle θ and $(90^o - \theta)$, to the horizontal with the same speed. The ratio of their maximum vertical heights is

(a) 1 : tanθ
(b) $\tan^2\theta : 1$
(c) 1 : 1
(d) tan θ : 1

Karnataka CET-2022

Ans. (b) : When object projected at an angle θ then,

$$H_1 = \frac{u^2 \sin^2\theta}{2g} \qquad \text{....(i)}$$

Now when object projected at an angle $(90^o - \theta)$ then,

$$H_2 = \frac{u^2 \sin^2(90° - \theta)}{2g} \qquad \text{....(ii)}$$

Now divide equation (i) by (ii), we get–

$$\frac{H_1}{H_2} = \frac{\dfrac{u^2 \sin^2\theta}{2g}}{\dfrac{u^2 \sin^2(90° - \theta)}{2g}}$$

$$\frac{H_1}{H_2} = \frac{u^2 \sin^2\theta}{u^2 \cos^2\theta}$$

$$\frac{H_1}{H_2} = \frac{\tan^2\theta}{1}$$

$$H_1 : H_2 = \tan^2\theta : 1$$

266. In projectile motion, the physical quantity that remains invariant throughout is

(a) vertical component of velocity
(b) horizontal component of velocity
(c) kinetic energy of the projectile
(d) potential energy of the projectile
(e) linear momentum of the projectile

Kerala CEE 04.07.2022
AP EAMCET (21.09.2020) Shift-II
Kerala CEE - 2017, 2012

Ans. (b) : Horizontal component of velocity remains constant for a projectile fired from the earth because there is no acceleration in horizontal direction.

267. A body is projected with an angle θ. The maximum height reached is h. If the time of flight is 4 sec and $g = 10\ m/s^2$, then the value of h is

(a) 10 m
(b) 40 m
(c) 20 m
(d) 5 m

AP EAMCET(Medical)-2014

Ans. (c) : Given that, T = 4 sec, $g = 10\ m/sec^2$

We know that,

$$T = \frac{2u\sin\theta}{g}$$

$$\frac{4\times 10}{2} = u\sin\theta$$

$$u\sin\theta = 20$$

Squaring both side we get–

$$u^2\sin^2\theta = (20)^2 \qquad \text{.....(i)}$$

$$\text{Now, height (h) } = \frac{u^2\sin^2\theta}{2g}$$

$$h = \frac{(20)^2}{2\times 10} = \frac{20\times 20}{20} = 20\,m$$

@apna_pdf

268. A body is projected horizontally from the top of a tower with a velocity of 10 m/s. If it hits the ground at an angle of 45°, the vertical component of velocity when it hits ground in m/s is

(a) 10
(b) $10\sqrt{2}$
(c) $5\sqrt{2}$
(d) 5

AP EAMCET(Medical)-2014

Ans. (a) : According to question

Horizontal component of velocity $(v_x) = u = 10\ ms^{-1}$

Then, $\tan\theta = \dfrac{v_y}{v_x}$

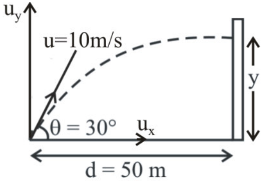
$$\tan 45^\circ = \frac{v_y}{10} \Rightarrow \quad v_y = 10\ ms^{-1}$$

269. An object is thrown towards the tower which is at a horizontal distance of 50 m with an initial velocity of $10ms^{-1}$ and making an angle 30° with the horizontal. The object hits the tower at certain height. The height from the bottom of the tower where the object hits the tower is ($g = 10ms^{-2}$)

(a) $\dfrac{50}{\sqrt{3}}\left[1-\dfrac{10}{\sqrt{3}}\right]m$
(b) $\dfrac{50}{3}\left[1-\dfrac{10}{\sqrt{3}}\right]m$
(c) $\dfrac{100}{\sqrt{3}}\left[1-\dfrac{10}{\sqrt{3}}\right]m$
(d) $\dfrac{100}{3}\left[1-\dfrac{10}{\sqrt{3}}\right]m$

AP EAMCET(Medical)-2015

Ans. (a) : Given, horizontal distance (x) = 50 m, initial velocity (u) = 10 ms^{-1}, angle (θ) = 30°, g = 10 ms^{-2}



So, according to question

$$u_x = u\cos\theta$$
$$u_x = 10\times\frac{\sqrt{3}}{2} \qquad (\because \theta = 30^\circ)$$
$$u_x = 5\sqrt{3}\ m/s$$

and $u_y = u\sin\theta$

$$u_y = 10\times\frac{1}{2} \qquad (\because \theta = 30^\circ)$$
$$u_y = 5\ m/s$$

Acceleration along x-axis $a_x = 0$

Acceleration along y-axis $a_y = -g$

Using equation of motion-

$$s = ut + \frac{1}{2}at^2$$

Along x-axis:-

$$x = u_xt + \frac{1}{2}a_xt^2$$
$$50 = 5\sqrt{3}t + \frac{1}{2}(0)t^2$$
$$t = \frac{50}{5\sqrt{3}} = \frac{10}{\sqrt{3}}\sec$$

Similarly, along y-axis–

$$y = u_yt + \frac{1}{2}a_yt^2$$
$$y = 5\times\frac{10}{\sqrt{3}} + \frac{1}{2}(-10)\left(\frac{10}{\sqrt{3}}\right)^2$$
$$y = 5\times\frac{10}{\sqrt{3}} - 5\left(\frac{10}{\sqrt{3}}\right)^2$$
$$y = \frac{50}{\sqrt{3}}\left[1-\frac{10}{\sqrt{3}}\right]m$$

Hence, the object hits the tower at $\dfrac{50}{\sqrt{3}}\left[1-\dfrac{10}{\sqrt{3}}\right]m$

270. Equations of motion of a projectile are given by x =36t m and 2y = 96t -9.8t²m. the angle of projection is equal to.

(a) $\sin^{-1}\left(\dfrac{3}{4}\right)$
(b) $\sin^{-1}\left(\dfrac{4}{3}\right)$
(c) $\sin^{-1}\left(\dfrac{4}{5}\right)$
(d) $\sin^{-1}\left(\dfrac{3}{5}\right)$

AP EMCET(Medical)-2011
AP EAMCET-2003

Ans. (c) : Given that-

$$x = 36\ t$$
$$2y = 96t–9.8t^2$$
$$y = 48t – 4.9t^2$$

So, Let initial velocity is u, and angle is θ.

Now, horizontal velocity $(u_x) = u\cos\theta = \left(\dfrac{dx}{dt}\right)_{t=0} = 36$

$$u\cos\theta = 36 \qquad \text{.....(i)}$$

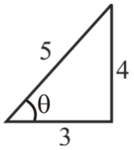
Vertical velocity $(u_y) = u\sin\theta = \left(\dfrac{dy}{dt}\right)_{t=0} = 48 - 9.8t$

$$u\sin\theta = 48 \qquad \text{....(ii)}$$

Dividing equation (ii) by equation (i), we get–

$$\tan\theta = \frac{48}{36} = \frac{4}{3}$$

Then from the Pythagoras theorem



The angle projection, $\sin\theta = \dfrac{4}{5} \Rightarrow \theta = \sin^{-1}\left(\dfrac{4}{5}\right)$

271. Two balls are projected simultaneously in the same vertical plane from the same point with velocities V_1 and V_2 with angles θ_1 and θ_2 respectively with the horizontal. If $V_1\cos\theta_1 = V_2\cos\theta_2$, the path of one ball as seen from the position of other ball is:

@apna_pdf

(a) Parabola
(b) Horizontal straight line
(c) Vertical straight line
(d) Straight line making 45^o with the vertical

AP EAMCET(Medical)-2005

Ans. (c) : Given that, $V_1 \cos\theta_1 = V_2 \cos\theta_2$
So, the relative velocity between them is 0. Path of one ball as seen from the position of the other ball will be vertical straight line.

272. The maximum height reached by a projectile is 4m. The horizontal range is 12m. Velocity of projection in ms^{-1} is: (g = acceleration due to gravity)

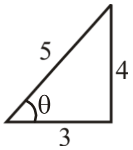
(a) $5\sqrt{\frac{g}{2}}$ (b) $3\frac{g}{\sqrt{2}}$
(c) $\frac{1}{3}\frac{g}{\sqrt{2}}$ (d) $\frac{1}{5}\sqrt{\frac{g}{2}}$

AP EAMCET(Medical)-2004
UP CPMT-2006

Ans. (a) : Given that, horizontal range (R) = 12 m, maximum height (H) = 4 m

We know that, $\tan\theta = \frac{4H}{R} = \frac{4\times4}{12} = \frac{4}{3}$

Then from the Pythagoras theorem



Then, $\sin\theta = \frac{4}{5}$

Now, $H = \frac{u^2\sin^2\theta}{2g} \Rightarrow u^2 = \frac{2gH}{\sin^2\theta}$

$$u^2 = \frac{2\times g\times4}{\left(\frac{4}{5}\right)^2} \Rightarrow u^2 = \frac{25\times8g}{16}$$

$$u = \sqrt{\frac{25\times g}{2}}$$

Velocity of projection (u) = $5\sqrt{\frac{g}{2}}$ m/s

273. Two stones are projected with the same speed but making different angles with the horizontal. Their horizontal ranges are equal. The angle of projection of one is π/3 and the maximum height reached by it is 102m. Then the maximum height reached by the other in m is :

(a) 336 (b) 224
(c) 56 (d) 34

BCECE-2008
AP EAMCET(Medical)-2003

Ans. (d) : Given that, angle of projection $(\theta_1) = \frac{\pi}{3}$

$$\theta_2 = \left(\frac{\pi}{2} - \frac{\pi}{3}\right) = \frac{\pi}{6}$$

$H_{max} = 102$ m and $R_1 = R_2$

So, $H_1 = \frac{u^2\sin^2\theta_1}{2g}$ ----- (i)

And, $H_2 = \frac{u^2\sin^2\theta_2}{2g}$ ----- (ii)

Dividing equation (i) by (ii), we get–

$$\frac{H_1}{H_2} = \frac{\frac{u^2\sin^2\theta_1}{2g}}{\frac{u^2\sin^2\theta_2}{2g}} = \frac{\sin^2\theta_1}{\sin^2\theta_2}$$

Then, $H_2 = \frac{H_1\sin^2\theta_2}{\sin^2\theta_1} = \frac{102\times[\sin(\pi/6)]^2}{[\sin(\pi/3)]^2} = 102\times\frac{1/4}{3/4}$

$H_2 = 34$ m

274. A projectile has initially the same horizontal velocity as it would acquire, if it had moved from rest with uniform acceleration of 3 ms^{-2} for 0.5 minute. If the maximum height reached by it is 80 m, then the angle of projection is: (g= $10ms^{-2}$)

(a) $\tan^{-1}(3)$ (b) $\tan^{-1}\left(\frac{3}{2}\right)$
(c) $\tan^{-1}\left(\frac{4}{9}\right)$ (d) $\sin^{-1}\left(\frac{4}{9}\right)$

AP EAMCET(Medical)-2002

Ans. (c) : Given, $a_x = 3m/s^2$, H = 80 m
Time (t) = 0.5 min = 0.5× 60 = 30 sec

We know, $H = \frac{u^2\sin^2\theta}{2g}$

$$80 = \frac{u^2\sin^2\theta}{2\times10}$$

$u\sin\theta = 40$ … (i)

Now, Horizontal velocity

$u\cos\theta = u + at$ (where u = 0)

$u\cos\theta = 3\times30 = 90$ … (ii)

On dividing (i) and (ii), we get

$$\frac{u\sin\theta}{u\cos\theta} = \frac{40}{90}$$

$$\tan\theta = \frac{4}{9} \Rightarrow \theta = \tan^{-1}\left(\frac{4}{9}\right)$$

275. It is possible to project a particle with a given speed in two possible ways so that, it has the same horizontal range R. The product of the times taken by it in two possible ways is : [g= acceleration due to gravity]

(a) $\frac{R}{g}$ (b) $\frac{2R}{g}$

@apna_pdf

(c) $\frac{3R}{g}$ (d) $\frac{4R}{g}$

AP EAMCET(Medical)-2001

Ans. (b) : Range of projectile (R) = $\frac{u^2 \sin 2\theta}{g}$

According to question, range is equal–

$R_1 = R_2$ and velocity is equal $(u_1 = u_2)$

Now, $\frac{u_1^2 \sin 2\theta_1}{g} = \frac{u_2^2 \sin 2\theta_2}{g}$

$\sin 2\theta_1 = \sin 2\theta_2$

$\sin 2\theta_1 = \sin(180° - 2\theta_2)$

$2\theta_1 = (180° - 2\theta_2)$

$\theta_1 = (90° - \theta_2)$ ...(i)

Time of flight (T) $= \frac{2u\sin\theta}{g}$

Product of time of flight

$$T_1 \times T_2 = \frac{2u_1 \sin\theta_1}{g} \times \frac{2u_2 \sin\theta_2}{g}$$

$$T_1 \times T_2 = \frac{4u^2 \sin\theta_1 \sin\theta_2}{g^2} \quad \{u_1 = u_2\}$$

Put the value of θ_1 from equation (i),

$$T_1 \times T_2 = \frac{4u^2 \sin\theta_2 \sin(90° - \theta_2)}{g^2} = \frac{2}{g} \times \frac{2u^2 \sin\theta_2 . \cos\theta_2}{g}$$

$$T_1 \times T_2 = \frac{2}{g} \times \frac{u^2 \sin 2\theta_2}{g}$$

$$T_1 \times T_2 = \frac{2R}{g}$$

276. A stone is projected with a velocity u at angle θ with the horizontal reaches maximum height H_1, when it is projected with a velocity u at an angle $\left(\frac{\pi}{2} - \theta\right)$ with the horizontal, it reaches to a maximum height H_2. The relation between the horizontal range r of the projectile, H_1 and H_2 is:

(a) $R = 4\sqrt{H_1 H_2}$ (b) $R = 4(H_1 - H_2)$

(c) $R = 4(H_1 + H_2)$ (d) $R = H_1^2 / H_2^2$

AP EAMCET(Medical)-2000

Ans. (a) : We know that,

Maximum height of projectile (H) = $\frac{u^2 \sin^2\theta}{2g}$

When stone is projected with velocity (u) and angle θ then,

$$H_1 = \frac{u^2 \sin^2\theta}{2g} \quad \text{...(i)}$$

When, projected with velocity (u) and angle $\left(\frac{\pi}{2} - \theta\right)$

Then, $H_2 = \frac{u^2 \sin^2\left(\frac{\pi}{2} - \theta\right)}{2g}$

$$H_2 = \frac{u^2 \cos^2\theta}{2g} \quad \text{..........(ii)}$$

Multiply from equation (i) and (ii)

$$H_1 \times H_2 = \frac{u^2 \sin^2\theta}{2g} \times \frac{u^2 \cos^2\theta}{2g}$$

$$H_1 \times H_2 = \frac{4}{4} \times \frac{u^4 \sin^2\theta \cos^2\theta}{4g^2}$$

$$H_1 \times H_2 = \frac{\left(u^2 2\sin\theta\cos\theta\right)^2}{16g^2}$$

$$H_1 \times H_2 = \frac{1}{16} \times \left(\frac{u^2 \sin 2\theta}{g}\right)^2$$

$$H_1 \times H_2 = \frac{1}{16} R^2 \quad \left\{\therefore R = \frac{u^2 \sin 2\theta}{g}\right\}$$

$$R = 4\sqrt{H_1 \times H_2}$$

277. For a projectile the ratio of maximum height reached to the square of flight time is: ($g = 10ms^{-2}$)

(a) 5:4 (b) 5:2 (c) 5:1 (d) 10:1

AP EAMCET(Medical)-2000

Ans. (a) : We know that,

Maximum height of projectile (H) = $\frac{u^2 \sin^2\theta}{2g}$

Flight time (T) = $\frac{2u\sin\theta}{g}$

According to question-

$$\frac{\text{Maximum height(H)}}{[\text{Time of flight (T)}]^2} = \frac{u^2 \sin^2\theta}{2g} \times \frac{g^2}{4u^2 \sin^2\theta}$$

$$\frac{H}{T^2} = \frac{g}{8} = \frac{10}{8} \quad \{\therefore g = 10ms^{-2}\}$$

$$\frac{H}{T^2} = \frac{5}{4}$$

$H : T^2 = 5 : 4$

278. The angle of projection of a projectile, for which the horizontal range and the maximum height are equal, is:

(a) $\tan^{-1}\left(\sqrt{(3)}\right)$ (b) $\tan^{-1}(4)$

(c) $\tan^{-1}\left(\sqrt{2}\right)$ (d) $\tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$

AP EAMCET(Medical)-1999
UPSEE-2013
J & K CET-2000
AIPMT-2011

@apna_pdf

Ans. (b) : We know that,

Maximum height of projectile (H) = $\dfrac{u^2 \sin^2\theta}{2g}$

Range (R) = $\dfrac{u^2 \sin 2\theta}{g}$

According to question-

$$H = R$$

$$\frac{u^2 \sin^2\theta}{2g} = \frac{u^2 \sin 2\theta}{g}$$

$$\frac{\sin^2\theta}{2} = 2\sin\theta\cos\theta$$

$$\frac{\sin\theta}{2} = 2\cos\theta$$

$$\tan\theta = 4$$

$$\theta = \tan^{-1}(4)$$

279. The trajectory of a projectile projected from origin is given by the equation $y = x - \dfrac{2x^2}{5}$. The initial velocity of the projectile is:

(a) $\dfrac{2}{5}$ ms^{-1} (b) 5 ms^{-1}

(c) 25 ms^{-1} (d) $\dfrac{5}{2}$ ms^{-1}

Karnataka CET-2019

Ans. (b) : Given,

$$y = x - \frac{2x^2}{5} \qquad \text{..... (i)}$$

We know,

Equation of projectile (y) = x tanθ – $\dfrac{gx^2}{2u^2\cos^2\theta}$ … (ii)

Comparing the equation (i) and (ii), we get–

$$\tan\theta = 1$$

$$\theta = 45°$$

And,

$$\frac{g}{2u^2\cos^2\theta} = \frac{2}{5}$$

$$\frac{10}{2u^2\cos^2\theta} = \frac{2}{5}$$

$$\frac{5}{u^2\cos^2\theta} = \frac{2}{5}$$

$$u^2 = \frac{5\times 5}{(\cos 45°)^2 \times 2}$$

$$u^2 = \frac{25}{\frac{1}{2}\times 2} \qquad \left[\therefore \cos 45° = \frac{1}{\sqrt{2}}\right]$$

$$u = 5\ \text{m/s}$$

280. Three projectiles A, B and C are projected at an angle of 30°, 45°, 60° respectively. If R_A, R_B and R_C are ranges of A, B and C respectively, then (velocity of projection is same for A, B and C) :

(a) $R_A = R_B = R_C$ (b) $R_A = R_C > R_B$

(c) $R_A < R_B < R_C$ (d) $R_A = R_C < R_B$

Karnataka CET-2016

Ans. (d) : Given, $\theta_A = 30°$, $\theta_B = 45°$, $\theta_C = 60°$

We know that,

Range of projectile motion (R) = $\dfrac{u^2 \sin 2\theta}{g}$

$R \propto \sin 2\theta$ { u is same for all}

For, $\theta_A = 30°$

$\sin 2\theta_A = \sin 60° = 0.866$

For $\theta_B = 45°$

$\sin 2\theta_B = \sin 90° = 1$

For $\theta_C = 60°$

$\sin 2\theta_C = \sin 120° = 0.866$

So, $R_A = R_C < R_B$

281. A stone is thrown vertically at a speed of 30 ms^{-1} taking an angle of 45^0 with the horizontal. What is the maximum height reached by the stone? Take g = 10 ms^{-2}.

(a) 30 m (b) 22.5 m

(c) 15 m (d) 10 m

Karnataka CET-2014

Ans. (b) : Given, u = 30 ms^{-1}, θ = 45^0, g = 10 ms^{-2}, maximum height (H) = ?

Maximum height of the projectile moving with velocity v at an angle θ is given by

$$H = \frac{u^2 \sin^2\theta}{2g}$$

$$H = \frac{30^2 \times \sin^2(45°)}{2\times 10}$$

$$H = \frac{900}{20} \times \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{900\times 1}{20\times 2}$$

$$H = 22.5\ \text{m}$$

282. A projectile is projected at 10 ms^{-1} by making at an angle 60^0 to the horizontal. After some time its velocity makes an angle of 30^0 to the horizontal. Its speed at this instant is:

(a) $\dfrac{10}{\sqrt{3}}$ (b) $10\sqrt{3}$

(c) $\dfrac{5}{\sqrt{3}}$ (d) $5\sqrt{3}$

Karnataka CET-2013

Ans. (a) : As the velocity makes an angle of 60° with horizontal. So, the horizontal component of velocity at the instant will be

$$v_x = 10\cos 60° = 10 \times 0.5 = 5\ \text{m/s}$$

When angle 30° then,

$$v_x = v\cos 30°$$

$$v\cos 30° = 5$$

@apna_pdf

$$v = \frac{5}{\cos 30°}$$

$$v = \frac{5}{\sqrt{3}/2} \qquad [\cos 30° = \frac{\sqrt{3}}{2}]$$

$$v = \frac{10}{\sqrt{3}}\ \text{m/s}$$

283. The height y and the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = (8t - 5t^2)$ m and $x = 6t$ m, where t is in seconds. The velocity with which the projectile is projected is:

(a) 6 ms^{-1} (b) 8 ms^{-1}
(c) 10 ms^{-1} (d) 14 ms^{-1}

MHT-CET 2020
Karnataka CET-2011
UP CPMT-2006
BCECE-2003

Ans. (c) : Given that, $x = 6t$, $y = 8t - 5t^2$

$$v_y = \frac{dy}{dt} = 8 - 10t$$

$$v_y = 8 - 10t$$

At t = 0,

$$v_y = 8 - 10 \times 0$$

$$v_y = 8\ \text{m/s}$$

$\because$ $x = 6t$

$$v_x = \frac{dx}{dt} = 6\ \text{m/s}$$

$\therefore$ The velocity of projectile, $\vec{u} = 6\hat{i} + 8\hat{j}$

$$= \sqrt{(v_x)^2 + (v_y)^2}$$

$$= \sqrt{(6)^2 + (8)^2} = \sqrt{36 + 64} = 10\ \text{m/s}$$

284. For a given velocity, a projectile has the same range R for two angles of projection t_1 and t_2 are the time of flight in the two cases then:

(a) $t_1 t_2 \propto R$ (b) $t_1 t_2 \propto R^2$
(c) $t_1 t_2 \propto \frac{1}{R^2}$ (d) $t_1 t_2 \propto \frac{1}{R}$

AP EAMCET-07.10.2020
SRMJEE-2019
BITSAT-2012
DCE-2009
Karnataka CET-2003
AP EAMCET -2012
AIEEE 2005, 04

Ans. (a) : We know, $t = \frac{2u\sin\theta}{g}$

$$R = \frac{u^2 \sin 2\theta}{g}$$

According to question, $R_1 = R_2$

$$\frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin 2\theta_2}{g} \qquad \text{(velocity is same)}$$

$$\sin 2\theta_1 = \sin 2\theta_2$$

$$\sin 2\theta_1 = \sin(180° - 2\theta_2)$$

$$2\theta_1 = 180° - 2\theta_2$$

$$\theta_1 = (90° - \theta_2)$$

Time of flight $(t_1) = \frac{2u\sin\theta_1}{g}$

$$t_1 = \frac{2u\sin(90° - \theta_2)}{g}$$

$$t_1 = \frac{2u\cos\theta_2}{g} \qquad \text{....(i)}$$

Similarly, $t_2 = \frac{2u\sin\theta_2}{g}$ ...(ii)

Equation (i) × (ii), we get-

$$t_1 t_2 = \frac{2u\sin\theta_2}{g} \times \frac{2u\cos\theta_2}{g}$$

$$t_1 t_2 = \frac{2}{g}\,\frac{2u^2\sin\theta_2\cos\theta_2}{g} \Rightarrow t_1 t_2 = \frac{2}{g}\,\frac{u^2\sin 2\theta_2}{g}$$

$$t_1 t_2 = \frac{2}{g}.R$$

So, $t_1.t_2 \propto R$

285. If a projectile is launched with velocity V_o' making an angle θ with x axis, then its time of flight T

(a) $T = \frac{V_o^2 \sin 2\theta}{g}$ (b) $T = \frac{V_o^2 \sin^2\theta}{2g}$
(c) $T = \frac{V_o^2}{g}$ (d) $T = \frac{2V_o \sin\theta}{g}$

J&K CET- 2011

Ans. (d) : We know,

Range = u_x × time of flight (T)

$$\frac{V_0^2 \sin 2\theta}{g} = V_0 \cos\theta \times T$$

$$T = \frac{V_0^2(2\sin\theta\cos\theta)}{g \times V_0\cos\theta}$$

Time of flight $(T) = \frac{2V_o \sin\theta}{g}$

286. The maximum range of a projectile is 100 m. The maximum height reached by it is

(a) 100 m (b) 25 m
(c) 200 m (d) 75 m

J&K CET- 2009

Ans. (b) : Horizontal range of a projectile,

$$R = \frac{u^2 \sin 2\theta}{g}$$

Where, u is the velocity of a projectile and θ is the angle of the projection with the horizontal.

The range is maximum when, θ = 45°.

@apna_pdf

$\therefore$ The maximum range is-

$$R_{max} = \frac{u^2 \sin 90°}{g} = \frac{u^2}{g} \text{ ………. (i)}$$

When, the range is maximum, the maximum height reached by the projectile is

$$H_{max} = \frac{u^2 \sin^2 \theta}{2g} = \frac{u^2 \sin^2 45°}{2g} = \frac{u^2\left(\frac{1}{\sqrt{2}}\right)^2}{2g}$$

$$H_{max} = \frac{u^2}{4g} = \frac{R_{max}}{4} \qquad \text{(given } R_{max} = 100)$$

$$\therefore\ H_{max} = \frac{100\text{m}}{4} = 25\,\text{m}$$

287. A body is projected at an angle θ with respect to horizontal direction with velocity u. The maximum range of the body is

(a) $R = \frac{u^2 \sin 2\theta}{g}$
(b) $R = \frac{u^2 \sin^2 \theta}{2g}$
(c) $R = \frac{u^2}{g}$
(d) $R = u^2 \sin\theta$

J&K CET- 2008

Ans. (c) : The range of projectile (R)= $\frac{u^2 \sin 2\theta}{g}$ …. (i)

For the maximum range-

$$\sin 2\theta = 1$$
$$\sin 2\theta = \sin 90^o$$
$$2\theta = 90°$$
$$\theta = 45^o$$

Putting the value of θ in equation (i), we get-

$$R = \frac{u^2}{g}\sin 90°$$

Maximum range of the projectile (R) = $\frac{u^2}{g}$

288. From the top of a tower a body A is projected vertically upwards, another body B is horizontally thrown and a third body C is thrown vertically downwards with the same velocity

(a) B strikes the ground with more velocity
(b) C strikes the ground with less velocity
(c) A, B, C, strike the ground with same velocity
(d) A and C strike the ground with more velocity than B

AP EAMCET (18.09.2020) Shift-I
J&K CET- 2007

Ans. (c) For body A – It goes with velocity u will reach its maximum height. Then the final velocity become 0 and comes back. It will attain velocity u.

Using Newton's law of motion,

$$v^2 = u^2 + 2as$$
$$v_A = \sqrt{u^2 + 2gh}$$

For body B – It is going down with velocity u.

$$v_B = \sqrt{u^2 + 2gh}$$

For body C – Its horizontal velocity remains same (i.e. u). Then,

Vertical velocity (v_y) = $\sqrt{0 + 2gh} = \sqrt{2gh}$

Resultant (v_C) = $\sqrt{v_x^2 + v_y^2} = \sqrt{u^2 + 2gh}$

Hence, $v_A = v_B = v_C$

289. Two bodies are projected from ground with equal speeds 20 m/sec from the same position in same vertical plane to have equal range but at different angle above the horizontal. If one of the angle is 30° the sum of their maximum heights is (assume g = 10 m/s^2)

(a) 400 m
(b) 20 m
(c) 30 m
(d) 40 m

J&K CET- 2006

Ans. (b) : Given, u = 20m/s, g = 10m/s^2

As the range of two projectiles are same, so the angle of projection must be complementary.

$$\theta_1 = 30,\ \theta_2 = 90 - \theta_1$$
$$= 90 - 30 = 60$$
$$\theta_2 = 60^o$$

The maximum height of projectile is given by

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

For $\theta_1 = 30^o$

$$H_1 = \frac{u^2 \sin^2 \theta_1}{2g} \Rightarrow H_1 = \frac{(20)^2 \times \sin^2 30^o}{2 \times 10}$$

$$H_1 = \frac{400 \times \left(\frac{1}{2}\right)^2}{2 \times 10} = \frac{400 \times 1}{4 \times 2 \times 10}$$

$$H_1 = 5\text{m}$$

For $\theta_2 = 60^o$

$$H_2 = \frac{u^2 \sin^2 \theta_2}{2g}$$

$$H_2 = \frac{(20)^2 \times \sin^2 60^o}{2 \times 10} = \frac{400 \times \left(\frac{\sqrt{3}}{2}\right)^2}{20} = 20 \times \frac{3}{4}$$

$$H_2 = 15\text{m}$$

Sum of maximum height (H) = $H_1 + H_2$
= 5 + 15
= 20 m

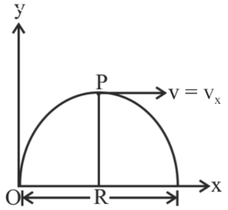
290. Neglecting the air resistance, the time of flight of a projectile is determined by

(a) $U_{vertical}$
(b) $U_{horizontal}$
(c) $U = U^2_{vertical} + U^2_{horizontal}$
(d) $U = (U^2_{vertical} + U^2_{horizontal})^{1/2}$

J&K CET- 2004

@apna_pdf

Ans. (a) : Let a body be projected at an initial velocity v in a direction making an angle θ with the horizontal and let it take time t to reach the highest point P of its path.



The vertical velocity of the body at P is zero.

From equation of motion, v = u – gt

Putting, $v = v_y = 0$

and $u = u_y = u\sin\theta$

$u\sin\theta = gt$

$$t = \frac{u\sin\theta}{g}$$

Hence, time of flight (T) is 2t.

∴ T = 2t

$$T = \frac{2u\sin\theta}{g} \Rightarrow T = \frac{2}{g}\times U_{vertical}$$

∴ Time of flight depends upon $U_{vertical}$.

291. The horizontal range of a projectile is $4\sqrt{3}$ times its maximum height. Its angle of projection will be

(a) 45° (b) 60°

(c) 90° (d) 30°

J&K CET- 2004, 2001, 1999,1998

Ans. (d) : We know that,

$$R = \frac{u^2\sin 2\theta}{g}$$

$$R = \frac{2u^2\sin\theta\cos\theta}{g} \quad ....(i) \quad [\because \sin 2\theta = 2\sin\theta.\cos\theta]$$

For maximum height,

$$H_{max} = \frac{u^2\sin^2\theta}{2g}$$

$$\text{Range} = 4\sqrt{3}\times \text{Height}_{max} \ \{\text{from equation (i)}\}$$

$$\frac{2u^2\sin\theta\cos\theta}{g} = 4\sqrt{3}\times\frac{u^2\sin^2\theta}{2g}$$

$$\cos\theta = \sqrt{3}\sin\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{1}{\sqrt{3}}$$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

$$\theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

$$\theta = 30^o$$

292. At the top of the trajectory of a projectile, the directions of its velocity and acceleration are

(a) Perpendicular to each other

(b) Parallel to each other

(c) Inclined to each other at an angle of 45°

(d) Antiparallel to each other

J&K CET- 2002

Ans. (a) : Direction of velocity is always tangent to the path so at the top of trajectory, it is in horizontal direction and acceleration due to gravity is always in vertically downward direction. It means angle between v and g are perpendicular to each other.

293. Two stones are projected with the same magnitude of velocity, but making different angles with horizontal, the angle of projection of one is π/3 and its maximum height is Y, the maximum height attained by the other stone with π/6 angle of projection is

(a) Y (b) 2Y

(c) 3Y (d) $\frac{Y}{3}$

J&K CET- 2000

Ans. (d) : Given, $\theta_1 = \pi/3$, $h_1 = Y$, $\theta_2 = \pi/6$

Let h_2 be the maximum height of other stone.

$$\text{We know, } h = \frac{u^2\sin^2\theta}{2g}$$

$$\frac{h_1}{h_2} = \frac{\sin^2\theta_1}{\sin^2\theta_2}$$

$$\frac{h_1}{h_2} = \frac{\sin^2(\pi/3)}{\sin^2(\pi/6)}$$

$$\frac{h_1}{h_2} = \frac{\left(\sqrt{3}/2\right)^2}{(1/2)^2} = \frac{3/4}{1/4}$$

$$\frac{h_1}{h_2} = \frac{3}{1}$$

$$h_2 = \frac{h_1}{3} \qquad [h_1 = Y]$$

$$\therefore \quad h_2 = \frac{Y}{3}$$

294. A projectile is projected at an angle of 47° relative to the horizontal. The range of the projectile could be increased by

(a) projecting it in a horizontal direction

(b) increasing the initial speed

(c) decreasing the projectional angle

(d) none of these

J&K CET- 1997

Ans. (b) : A projectile is projected at an angle of 47° relative to the horizontal. The range of the projectile could be increased by initial speed.

$$\text{Range of a projectile (R)} = \frac{u^2\sin 2\theta}{g}$$

Relation between R and u^2 is $R \propto u^2$ because angle 47° is fixed.

@apna_pdf

295. A ball is thrown horizontally from a height of 100 m with an initial speed of 15 m s^{-1}. How far does it travel horizontally in the first 2 seconds?

(a) 3 m (b) 7.5 m
(c) 30 m (d) 0.3 m

J&K-CET-2018

Ans. (c) : Given that, u = 15 m/s, t = 2 sec

$\because$ Horizontal distance = u × t

$= 15 \times 2$

$= 30$ m

296. A projectile is thrown with initial velocity v_0 and angle 30° with the horizontal. If it remains in the air for 1 sec, what was its initial velocity?

(a) 19.6m/s (b) 9.8m/s
(c) 4.9 m/s (d) 1 m/s

J&K-CET-2013

Ans. (b) : As we know that time of flight in projectile motion is given by $T = \frac{2u\sin\theta}{g}$

It is given that,

T = 1 sec, θ = 30°

$u = u_0$ (initial velocity)

Take $g = 9.8 \text{ m/s}^2$

Time of flight in projectile motion

$$1 = \frac{2u_0\sin 30°}{9.8} \Rightarrow v_0 = \frac{9.8}{2\times\sin 30°}$$

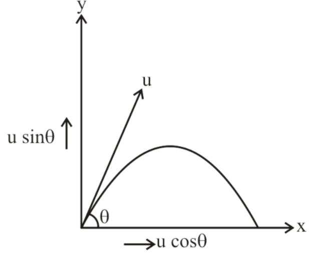
$$v_0 = 9.8 \text{ m/s}$$

297. A bird flies at an angle of 60° to the horizontal. Its horizontal component of velocity is 10 m s^{-1}. Find the vertical component of velocity in m s^{-1}

(a) $10\sqrt{3}$ (b) $\frac{10}{\sqrt{3}}$
(c) 5 (d) 26

J&K-CET-2017

Ans. (a) : Given, θ = 60º, u_x = 10m/s, u_y = ?



Horizontal component of velocity-

$u_x = u\cos\theta$

$10 = u\cos\theta$

$10 = u\cos 60°$

$10 = u\times\frac{1}{2}$

or $u = 20$ m/s

Vertical component of velocity-

$u_y = u\sin\theta$

$u_y = 20\times\sin 60°$

$u_y = 20\times\frac{\sqrt{3}}{2}$

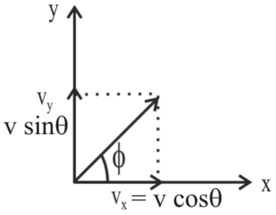
or $u_y = 10\sqrt{3}$ m/s

298. The angle which the velocity vector of a projectile thrown with a velocity v at an angle θ to the horizontal will make with the horizontal after time t of its being thrown up is:

(a) θ (b) $\tan^{-1}(\theta/t)$
(c) $\tan^{-1}\left(\frac{v\cos\theta}{v\sin\theta - gt}\right)$ (d) $\tan^{-1}\left(\frac{v\sin\theta - gt}{v\cos\theta}\right)$

MHT-CET 2020

Ans. (d) : As in given question the graph of projectile will be given as



Vertical velocity of projectile after time

t is v sinθ – gt (from equation of motion)

Angle at any time t,

$$\tan\phi = \frac{v_y}{v_x} = \frac{v\sin\theta - gt}{v\cos\theta}$$

$$\phi = \tan^{-1}\left(\frac{v\sin\theta - gt}{v\cos\theta}\right)$$

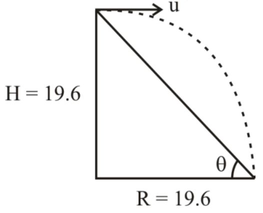
299. From the top of a tower 19.6 m high, a ball is thrown horizontally. If the line joining the point of projection to the point where it hits the ground makes an angle of 45^0 with the horizontal, then the time initial velocity of the ball is

(a) 9.8 ms^{-1} (b) 4.9 ms^{-1}
(c) 14.7 ms^{-1} (d) 2.8 ms^{-1}

MHT-CET 2020

Ans. (a) : Given, θ = 45º, g = 9.8m/s

Top of tower height (H) = 19.6m



$\because$ θ = 45°

and $\tan\theta = \frac{H}{R}$

$\tan 45° = \frac{H}{R}$

R = H = 19.6 m

In Horizontal direction

R = 19.6 = u × t ……(1)

@apna_pdf

In vertical direction

$$t = \sqrt{\frac{2H}{g}}$$

$$t = \sqrt{\frac{2 \times 19.6}{9.8}}$$

$$t = \sqrt{4}$$

$$t = 2 \text{ sec}$$

By putting value of t in equation (1), we get-

$$19.6 = u \times t$$

$$19.6 = u \times 2$$

$$u = \frac{19.6}{2}$$

$$u = 9.8 \text{ m/s}$$

300. A ball is thrown at two different angles with the same speed v and from the same point and it has the same range in both the cases. If y_1 and y_2 be the heights attained in the two cases, then $y_1 + y_2$ = ...:

(a) u^2/g (b) $2u^2/g$

(c) $u^2/2g$ (d) $u^2/4g$

MHT-CET 2020

Ans. (c) : Same range can be obtained from complementary angles i.e. θ and (90º–θ)

Height attained by I^st^ ball $y_1 = \frac{u^2 \sin^2\theta}{2g}$

Height attained by II^nd^ ball

$$y_2 = \frac{u^2 \sin^2(90-\theta)}{2g} = \frac{u^2\cos^2\theta}{2g}$$

$$\therefore \quad y_1 + y_2 = \frac{u^2\sin^2\theta}{2g} + \frac{u^2\cos^2\theta}{2g}$$

$$= \frac{u^2\sin^2\theta + u^2\cos^2\theta}{2g}$$

$$= \frac{u^2(\sin^2\theta+\cos^2\theta)}{2g} \qquad [\sin^2\theta+\cos^2\theta = 1]$$

$$= \frac{u^2}{2g}$$

301. At what angle with the horizontal should a ball be thrown so that its range R is related to the time of flight as $R = 5T^2$. (Take $g = 10ms^{-2}$)

(a) 30^0 (b) 45^0

(c) 60^0 (d) 90^0

MHT-CET 2020

Ans. (b) : Given, $R = 5T^2$, $g = 10m/s^2$

$$\text{Range (R)} = \frac{u^2\sin 2\theta}{g}$$

$$\text{Time of flight (T)} = \frac{2u\sin\theta}{g}$$

Since, $R = 5T^2$

$$\therefore \quad \frac{u^2\sin 2\theta}{g} = 5 \times \frac{4u^2\sin^2\theta}{g^2}$$

$$\sin 2\theta = \frac{20 \times \sin\theta.\sin\theta}{g}$$

$$2\sin\theta\cos\theta = 20 \times \frac{\sin\theta\sin\theta}{g}$$

$$2g\sin\theta\cos\theta = 20 \times \sin\theta\sin\theta$$

$$2 \times 10\cos\theta = 20\sin\theta$$

$$\cos\theta = \sin\theta$$

$$\frac{\sin\theta}{\cos\theta} = 1$$

$$\tan\theta = 1$$

$$\theta = 45^o$$

302. The maximum height attained by a projectile is increased by 10%. Keeping the angle of projection constant, what is percentage increase in the time of flight?

(a) 5% (b) 10%

(c) 20% (d) 40%

MHT-CET 2020

Ans. (a) : We know,

$$H = \frac{u^2\sin^2\theta}{2g} \quad ......(1)$$

$$\text{Time of flight } T = \frac{2u\sin\theta}{g} \quad ....(2)$$

Squaring on both side of equation (2), we get-

$$T^2 = \left(\frac{2u\sin\theta}{g}\right)^2 = \frac{4u^2\sin^2\theta}{g^2}$$

$$u^2\sin^2\theta = \frac{T^2 \times g^2}{4} \qquad .....(2)$$

Putting the value of $u^2\sin^2\theta$ from equation (1), we get-

$$H \times 2g = \frac{T^2 \times g^2}{4}$$

$$H = T^2\left(\frac{g}{8}\right)$$

$$\frac{g}{8} \rightarrow \text{constant}$$

So,

$$\frac{\Delta H}{H} = \frac{2\Delta T}{T}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta H}{H}$$

$$\frac{\Delta T}{T} \times 100 = \frac{1}{2}\left(\frac{\Delta H}{H} \times 100\right) \quad \left(\because \frac{\Delta H}{H} \times 100 = 10\right)$$

$$\frac{\Delta T}{T} \times 100 = \frac{1}{2} \times 10$$

$$\frac{\Delta T}{T} \times 100 = 5$$

% increases in T = 5%

@apna_pdf

303. Four projectiles are fixed with the same velocities at angles 25°, 40°, 55° and 70° with the horizontal. The range of projectile will be largest for the one projected at angle

(a) 25° (b) 40°
(c) 55° (d) 70°

AP EAMCET (23.09.2020) Shift-I

Ans. (b) : Given, $\theta_1 = 25°$, $\theta_2 = 40°$, $\theta_3 = 55°$ and $\theta_4 = 70°$

We know,

$$\text{Range, } R = \frac{u^2 \sin 2\theta}{g}$$

Then, $R \propto \sin 2\theta$

i.e. higher value of $\sin 2\theta$, range will also be greater.

Among the given values of projection angle, the value of $\sin 2\theta$ is greatest for $\theta = 40°$

So, range will be highest for projected angle $\theta = 40°$.

304. A projectile has the maximum range 500 m. If the projectile is thrown up an inclined plane of 30° with the same (magnitude) velocity, the distance covered by it along the inclined plane will be

(a) 250 m (b) 500 m
(c) 400 m (d) 1000 m

Manipal UGET-2016

Ans. (b) : Given that,

Maximum Range = 500m

For maximum range $\theta = 45°$

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$500 = \frac{u^2 \sin(2\times 45°)}{g}$$

$$500 = \frac{u^2 \times \sin 90°}{g} \qquad (\because \sin 90° = 1)$$

$$500 = \frac{u^2}{g} \qquad .....(i)$$

The distance covered along the inclined plane can be obtain using the equation

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$0 - u^2 = 2(-g\sin 30°)s \qquad [a = -g\sin 30°]$$

$$s = \frac{u^2}{g}$$

Putting the value of $\frac{u^2}{g}$ in equation (i)

$$\therefore \quad s = \frac{u^2}{g} = 500$$

So, $s = 500$ m

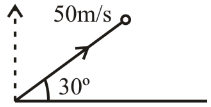
305. A stone is projected from the ground with velocity 50 m/s at an angle 30° with horizontal. It crosses a wall after 3 s. How far beyond the wall the stone will strike the ground? (g = 10 m/s²) ?

(a) 90.2 m (b) 12.5 m
(c) 86.5 m (d) $125\sqrt{3}$ m

Manipal UGET-2016

Ans. (c) : Given that,

u = 50m/s, θ=30°, time to cross the wall = 3 sec



$$\text{Time of flight (T)} = \frac{2u\sin\theta}{g}$$

$$T = \frac{2\times 50\times \sin 30°}{10}$$

$$T = \frac{2\times 50\times 1}{10\times 2}$$

T = 5 second

Time in air after crossing the wall = (5 – 3) = 2 sec

$T_2 = 2$ sec

Distance (d) = $u\cos\theta \times T_2$

$= 50 \times \cos 30° \times 2$

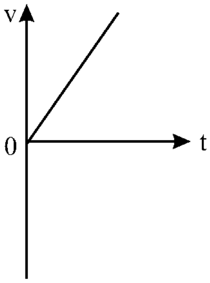
$$= \frac{50\times\sqrt{3}\times 2}{2}$$

$$d = 50\sqrt{3} \qquad [\sqrt{3} = 1.732]$$

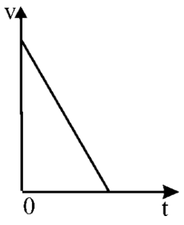
d = 86.5m

306. Which of the following graphs represents the speed v of a projectile as a function of time t?

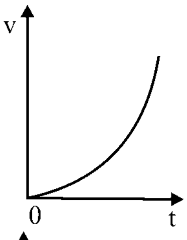
(a)



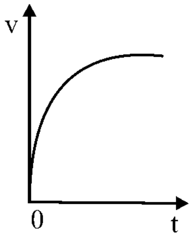
(b)



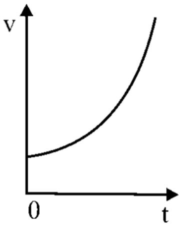
(c)



(d)



(e)



Kerala CEE -2018

@apna_pdf

Ans. (b) : As we know that in projectile motion, speed (v) of the projectile is decreases with time (t). So here option (b) graphs correctly represent the speed (v) of a projectile as a function of time.

307. From the ground, a projectile is fired at an angle of 60 degrees to the horizontal with a speed of 20 m/s. Take, acceleration due to gravity as 10 m/s^2 . The horizontal range of the projectile is

(a) $10\sqrt{3}$m (b) 20 m
(c) $20\sqrt{3}$m (d) $40\sqrt{3}$m
(e) $400\sqrt{3}$m

Kerala CEE - 2017

Ans. (c) : Given that,
Projectile speed (u) = 20 m/sec
Projectile angle (θ) = 60°
Acceleration due to gravity (g) = 10 m/sec^2
The horizontal range,

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$R = \frac{20^2 \sin 120°}{10}$$

$$R = \frac{20\times 20\times\sqrt{3}}{2\times 10}$$

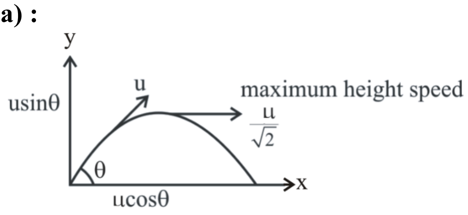
$$R = 20\sqrt{3}\text{m}$$

308. A body is thrown up with a speed u, at an angle of projection θ. If the speed of the projectile becomes $\frac{u}{\sqrt{2}}$ on reaching the maximum height, then the maximum vertical height attained by the projectile is

(a) $\frac{u^2}{4g}$ (b) $\frac{u^2}{3g}$
(c) $\frac{u^2}{2g}$ (d) $\frac{u^2}{g}$
(e) $\frac{2u^2}{g}$

Kerala CEE - 2016

Ans. (a) :



The speed of projectile at maximum height = u cosθ

$$u\cos\theta = \frac{u}{\sqrt{2}} \Rightarrow \cos\theta = \frac{1}{\sqrt{2}} = \cos 45°$$

θ = 45°

The maximum height is given by the formula,

$$H = \frac{u^2\sin^2\theta}{2g}$$

$$H = \frac{u^2\sin^2 45°}{2g} = \frac{u^2}{2g}\left(\frac{1}{\sqrt{2}}\right)^2$$

$$H = \frac{u^2}{4g}$$

309. The vertical component of velocity of a projectile at its maximum height (u = velocity of projection, θ = angle of projection) is

(a) u sin θ (b) u cos θ
(c) $\frac{u}{\sin\theta}$ (d) zero
(e) $\frac{u}{\cos\theta}$

Kerala CEE- 2014

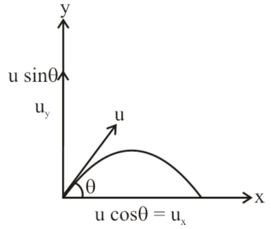
Ans. (d) : The vertical component of velocity of a projectile motion become zero at maximum height because the gravity acts in the vertically downward direction which produce retardation.
So, at maximum height vertical component of velocity of projectile motion become zero.

310. A body projected at an angle with the horizontal has a range 300 m. If the time of flight is 6 s, then the horizontal component of velocity is

(a) 30 ms^{-1} (b) 50 ms^{-1}
(c) 40 ms^{-1} (d) 45 ms^{-1}
(e) $30\sqrt{2}$ ms^{-1}

Kerala CEE- 2013

Ans. (b) : Given that,
Range R = 300 m
T = 6 s



We know,

$$R = \frac{u^2\sin 2\theta}{g} \text{ and } T = \frac{2u\sin\theta}{g}$$

$$[\because \sin 2\theta = 2\sin\theta\cos\theta]$$

$$R = \frac{u^2 2\sin\theta\cos\theta}{g} = \frac{2u\sin\theta}{g}\cdot u\cos\theta$$

$$R = T(u\cos\theta) \quad \left[\because T = \frac{2u\sin\theta}{g}\right]$$

300 = 6(u cosθ)

$$u\cos\theta = \frac{300}{6} = 50\text{ms}^{-1}$$

Hence, horizontal component of velocity is 50 ms^{-1}.

@apna_pdf

311. Two projectiles A and B thrown with speeds in the ratio $1:\sqrt{2}$ acquired the same heights. If A is thrown at an angle of 45º with the horizontal, the angle of projection of B will be

(a) 0º (b) 60º
(c) 30º (d) 45º
(e) 15º

Kerala CEE - 2011

Ans. (c) : Given,

$$\text{Angle } (\theta_a) = 45° \text{ and } \frac{u_a}{u_b} = \frac{1}{\sqrt{2}}$$

We know that,

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

Where, u = speed and θ = angle and A and B have same height.

$$\frac{u_a^2 \sin^2 45°}{2g} = \frac{u_b^2 \sin^2 \theta_b}{2g}$$

$$\sin^2 \theta_b = \left(\frac{u_a^2}{u_b^2}\right) \sin^2 45°$$

$$\sin^2 \theta_b = \left(\frac{1}{\sqrt{2}}\right)^2 \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$\sin^2 \theta_b = \frac{1}{4} \Rightarrow \sin \theta_b = \frac{1}{2}$$

$$\theta_b = 30°$$

312. The maximum height of a projectile is half of its range on the horizontal. If the velocity of projection is u, its range on the horizontal is

(a) $\frac{2u^2}{5g}$ (b) $\frac{3u^2}{5g}$
(c) $\frac{u^2}{g}$ (d) $\frac{u^2}{5g}$
(e) $\frac{4u^2}{5g}$

AP EAMCET- (17.09.2020) Shift-I
Kerala CEE - 2010
Karnataka CET-2015

Ans. (e) : Given,

$$\text{Maximum height} = \frac{1}{2} \text{range} \text{———(i)}$$

And velocity of projection = u

$$\text{Range (R)} = \frac{u^2 \sin 2\theta}{g}$$

$$\text{Maximum height (H)} = \frac{u^2 \sin^2 \theta}{2g}$$

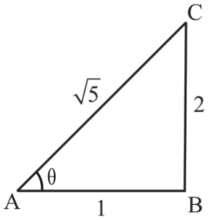
Putting the value of range in equation (i) we get

$$\text{Maximum height} = \frac{1}{2} \times \frac{u^2 \sin 2\theta}{g}$$

$$\frac{u^2 \sin^2 \theta}{2g} = \frac{u^2 \sin 2\theta}{g} \times \frac{1}{2}$$

$$\frac{\sin^2 \theta}{2} = \frac{2 \sin \theta \times \cos \theta}{2} \quad \{\therefore \sin 2\theta = 2 \sin \theta . \cos \theta\}$$

$$\tan \theta = 2$$



$$\because \quad \sin \theta = \frac{2}{\sqrt{5}}, \cos\theta = \frac{1}{\sqrt{5}}$$

$$\text{Horizontal range (R)} = \frac{2u^2 \sin \theta . \cos \theta}{g}$$

$$\therefore \sin \theta = \frac{2}{\sqrt{5}}, \cos \theta = \frac{1}{\sqrt{5}}$$

$$\text{Horizontal range (R)} = \frac{2u^2 \sin \theta . \cos \theta}{g}$$

$$R = \frac{2u^2 \times \frac{2}{\sqrt{5}} \times \frac{1}{\sqrt{5}}}{g}$$

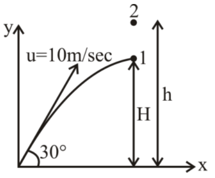
$$R = \frac{4u^2}{5g}$$

313. A ball is projected from the ground at a speed of 10 ms^{-1} making an angle of 30º with the horizontal. Another ball is simultaneously released from a point on the vertical line along the maximum height of the projectile. The initial height of the second ball is (g = 10 ms^{-2})

(a) 6.25 m (b) 2.5 m
(c) 3.75 m (d) 5 m
(e) 1.25 m

Kerala CEE 2007

Ans. (b) : Given, speed of ball (u) = 10 m/sec, angle (θ) = 30°, g = 10 m /sec^2



$$\text{Maximum height of projectile (H)} = \frac{u^2 \sin^2 \theta}{2g}$$

$$H = \frac{(10)^2 \sin^2 30º}{2 \times 10}$$

$$H = 5 \times \left(\frac{1}{2}\right)^2 \quad \left\{\because \sin 30º = \frac{1}{2}\right\}$$

$$H = \frac{5}{2 \times 2} = 1.25\text{m}$$

@apna_pdf

The first ball will take time to reach the maximum height is T/2

$$T = \frac{u\sin\theta}{g} \Rightarrow T = \frac{10\times\sin 30°}{10}$$

$$T = \frac{1}{2} = 0.5\,\text{sec}$$

The second ball is released from the point. It will travel a distance in 0.5 seconds.

$$s = ut + \frac{1}{2}gt^2$$

$$s = 0 + \frac{1}{2}(10)\times(0.5)^2$$

$$s = \frac{10\times0.5\times0.5}{2} = 5\times0.5\times0.5$$

s = 1. 25 m

The initial height of the 2nd ball will be = s + H

1.25 + 1.25 = 2.5 m

314. An object is projected at an angle of 45° with the horizontal. The horizontal range and maximum height reached will be in the ratio:

(a) 1 : 2
(b) 2 : 1
(c) 1 : 4
(d) 4 : 1
(e) $4:\sqrt{2}$

J&K CET- 2010
Kerala CEE 2005

Ans. (d) : Given,

Angle of projection (θ) = 45°

Horizontal range of projectile (R) = $\frac{u^2\sin 2\theta}{g}$

$$R = \frac{u^2\sin 2\times45°}{g}$$

$$R = \frac{u^2\sin 90°}{g} = \frac{u^2\times1}{g}$$

$$R = \frac{u^2}{g}$$

Maximum height of projectile (H) = $\frac{u^2\sin^2\theta}{2g}$

$$H = \frac{u^2\sin^2 45°}{2\times g}$$

$$H = \frac{u^2\times\left(\frac{1}{\sqrt{2}}\right)^2}{2g} = \frac{u^2}{2}\times\frac{1}{2g} \Rightarrow H = \frac{u^2}{4g}$$

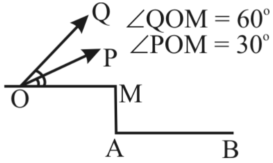
The ratio of horizontal range and maximum height is

$$\frac{R}{H} = \frac{\frac{u^2}{g}}{\frac{u^2}{4g}} = \frac{u^2}{g}\times\frac{4g}{u^2}$$

$$\frac{R}{H} = \frac{4}{1} \text{ or } 4:1$$

Hence, R : H = 4:1

315. Two identical balls P and Q are projected with same speeds in vertical plane from same point O with making projection angles with horizontal 30° and 60°, respectively and they fall directly on a plane AB at points P' and Q' respectively. Which of the following statement is true about distance as given in option?



∠QOM = 60°
∠POM = 30°

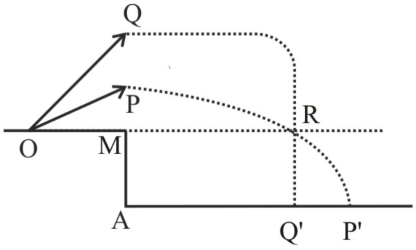
(a) AP' > AQ'
(b) AP' < AQ'
(c) AP' ≤ AQ'
(d) As there are complimentary projection angles

UPSEE - 2017

Ans. (a) : Given that,

Projection angle of ball P = 30°

and projection angle of ball Q = 60°



For complimentary angle ranges, OR is same for P and Q as O and R are on same horizontal plane.

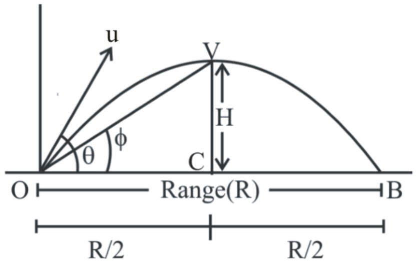
From figure we can say that AP' > AQ'

316. A projectile is fixed from level ground at an angle θ above the horizontal. The elevation angle ϕ of the highest point as seen from the launch point is related to θ by the relation.

(a) $\tan\phi = \frac{1}{4}\tan\theta$
(b) $\tan\phi = \tan\theta$
(c) $\tan\phi = \frac{1}{2}\tan\theta$
(d) $\tan\phi = 2\tan\theta$

UPSEE - 2013

Ans. (c) :



From figure,

$$\tan\phi = \frac{VC}{OC} = \frac{H}{R/2} = \frac{2H}{R}$$

For projectile motion,

Height (H) = $\frac{u^2\sin^2\theta}{2g}$

@apna_pdf

Range (R) = $\frac{u^2 \sin 2\theta}{2g}$

So,

$$\tan\phi = \frac{2H}{R} = \frac{\frac{2u^2\sin^2\theta}{2g}}{\frac{u^2\sin 2\theta}{g}} = \frac{\sin^2\theta}{\sin 2\theta}$$

$$\tan\phi = \frac{\sin^2\theta}{2\sin\theta.\cos\theta} = \frac{1}{2}\frac{\sin\theta}{\cos\theta}$$

$$\tan\phi = \frac{\tan\theta}{2}$$

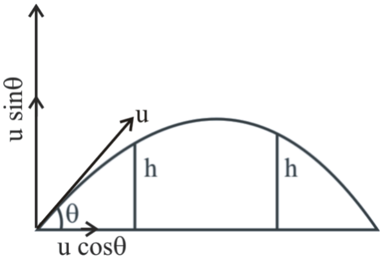
So, $\tan\phi = \frac{1}{2}\tan\theta$

317. A particle is projected with velocity $\sqrt{2gh}$, such that it just crosses two walls of height h and separated by h. Find the angle of projection.

(a) 15°
(b) 75°
(c) 60°
(d) 30°

UPSEE - 2010

Ans. (d) : Given, u = $\sqrt{2gh}$



Vertically upward motion,

$$y = ut - \frac{1}{2}gt^2$$

and, $h = (u\sin\theta)t - \frac{1}{2}gt^2$

$$gt^2 - 2u\sin\theta.t + 2h = 0$$

$$\therefore\ t = \frac{2u\sin\theta \pm \sqrt{(4u^2\sin^2\theta) - 8gh}}{2g}$$

If there are two roots of quadratic equation then,

$$t_1 = \frac{2u\sin\theta + \sqrt{(4u^2\sin^2\theta) - 8gh}}{2g} \quad \text{..... (i)}$$

$$t_2 = \frac{2u\sin\theta - \sqrt{(4u^2\sin^2\theta) - 8gh}}{2g} \quad \text{..... (ii)}$$

If particle cross the wall at times t_1 and t_2 respectively then,

$$t^2 = (t_1.t_2) \quad \text{.......(iii)}$$

Total time of flight is given by,

$$t = \frac{2u\sin\theta}{g} \quad \text{.....(iv)}$$

Putting the value of equation (i), (ii) and (iv) in equation (iii),

$$\left(\frac{2u\sin\theta}{g}\right)^2 = \frac{(2u\sin\theta)^2 - (4u^2\sin^2\theta - 8gh)}{4g^2}$$

$$\frac{4u^2\sin^2\theta}{g^2} = \frac{8gh}{4g^2} \qquad (\because u = \sqrt{2gh})$$

$$\therefore\ 2(2gh)\sin^2\theta = gh$$

$$\sin^2\theta = \frac{1}{4}$$

$$\sin\theta = \frac{1}{2} = \sin 30°$$

$$\theta = 30°$$

318. An artillary piece which consistently shoots its shells with the same muzzle speed has a maximum range R. To hit a target which is $\frac{R}{2}$ from the gun and on the same level, the elevation angle of the gun should be

(a) 15°
(b) 45°
(c) 30°
(d) 60°

UPSEE - 2009

Ans. (a) : Let initial velocity = u and angle = θ

We know,

Then maximum range (R) = $\frac{u^2\sin 2\theta}{g}$ ....(i)

Let for range R/2 angle is ϕ

So, $\frac{R}{2} = \frac{u^2\sin 2\phi}{g}$ ....(ii)

Put the value R in equation (ii) we get

$$\frac{u^2\sin 2\theta}{2g} = \frac{u^2\sin 2\phi}{g} \Rightarrow \frac{\sin 2\theta}{2} = \sin 2\phi$$

For maximum range θ must be 45°

$$\sin 2\phi = \frac{\sin(2\times 45°)}{2}$$

$$\sin 2\phi = \frac{\sin 90°}{2} \Rightarrow \sin 2\phi = \frac{1}{2} = \sin 30°$$

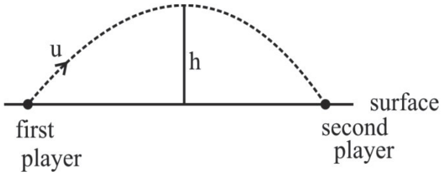
$$2\phi = 30° \Rightarrow \phi = 15°$$

319. A ball thrown by one player reaches the other in 2s. The maximum height attained by the ball above the point of projection will be ($g = 10\ m/s^2$)

(a) 2.5 m
(b) 5 m
(c) 7.5 m
(d) 10 m

UPSEE - 2008

Ans. (b) : Given, T = 2sec



@apna_pdf

We know,

Total time of flight $T = \dfrac{2u\sin\theta}{g} = 2$ sec

$$\sin\theta = \frac{g}{u} \qquad \text{........(i)}$$

$$H_{max} = \frac{u^2\sin^2\theta}{2g} = \frac{u^2}{2g}\times\frac{g^2}{u^2} \quad \text{[from equ. (i)]}$$

$$H_{max} = \frac{g}{2} \Rightarrow H_{max} = \frac{10}{2}$$

$H_{max} = 5$ m

320. A ball is thrown from a point with a speed v_0 at an angle of projection θ. From the same point and at the same instant, a person starts running with a constant speed $\frac{v_0}{2}$ to catch the ball. Will the person be able to catch the ball? If yes, what should be the angle of projection?

(a) Yes, 60º (b) Yes, 30º
(c) No (d) Yes, 45º

UPSEE - 2007
AIIMS - 2016
BCECE - 2004
JCECE - 2008
AIEEE-2004
UPCPMT-2018

Ans. (a) : Given,
Initial velocity of the ball = v_o
Angle of projection = θ

Constant speed of person $= \dfrac{v_o}{2}$

We know, horizontal component of velocity of the ball $= v_0\cos\theta$

Person will be able to catch the ball if his velocity is the same as the horizontal component of velocity of the ball i.e.

$$\frac{v_o}{2} = v_o\cos\theta$$

$$\cos\theta = \frac{1}{2} = \cos 60^o$$

$\theta = 60°$

If the person has to catch the ball then, angle of projection of the ball must be 60°.

321. A projectile is thrown in the upward direction making an angle of 60º with the horizontal direction with a velocity of 147 ms^{-1}. Then the time after which its inclination with the horizontal is 45º, is :

(a) 15 s (b) 10.98 s
(c) 5.49 s (d) 2.745 s

UPSEE - 2006
JCECE - 2007

Ans. (c) : Given,
Angle (θ) = 60°
Initial velocity (u) = 147 m/sec

Horizontal component of velocity at 60° = Horizontal component of velocity at 45°

u cos60° = v cos45°

$$147\times\frac{1}{2} = v\times\frac{1}{\sqrt{2}}$$

$$v = \frac{147}{\sqrt{2}}\,m/s$$

Vertical component of u = u sin 60° = u_y

$$= \frac{147\sqrt{3}}{2}\,m/s$$

Vertical component of v = v sin45° = v_y

$$\frac{147}{\sqrt{2}}\times\frac{1}{\sqrt{2}} = \frac{147}{2}\,m/s$$

From equation of motion

$$v_y = u_y - gt$$

$$\frac{147}{2} = \frac{147\sqrt{3}}{2} - 9.8t$$

$$9.8\,t = \frac{147}{2}(\sqrt{3}-1)$$

$t = 5.49$ sec

322. A ball is hit at 45º to the horizontal with a kinetic energy E_k. The kinetic energy at the highest point is :

(a) E_k (b) $\dfrac{E_k}{2}$
(c) $\dfrac{E_k}{\sqrt{2}}$ (d) zero

UPSEE - 2005
ASSAM CEE- 2014

Ans. (b) : Given, $\theta = 45°$
At highest point there will be only horizontal velocity so, the kinetic energy will be only due to horizontal velocity.
Initial kinetic energy (K_i) = E_k

$$k' = E_k\cos^2 45°$$

$$= E_k\left(\frac{1}{\sqrt{2}}\right)^2$$

$$k' = \frac{E_k}{2}$$

So,

Kinetic energy at top most point is $\dfrac{E_k}{2}$.

323. A boy travelling in an open car moving at constant velocity throws a ball vertically up into air. The ball falls

(a) outside the car
(b) in the car ahead of the boy
(c) in the car beside the boy
(d) exactly in his hand

AP EAMCET (22.09.2020) Shift-II

@apna_pdf

Ans. (d) : Since the car is moving with a constant velocity so acceleration will be zero.

∴ Distance travelled by the car in time t

$$s = ut + \frac{1}{2} \times 0 \times t^2$$

$$s = ut$$

Similarly, considering that the horizontal velocity of the ball is u. The distance travelled by the car in time t

$$s = ut$$

It means that the ball will cover the same distance as that of the car in time, t. Hence, the ball will land in the hands of the person who threw the ball.

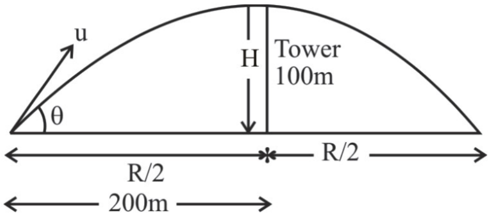
324. A shot is fired from a point at a distance of 200m, from the foot of a tower 100 m high, so that it just passes over it. The direction of shot with respect to the horizontal is

(a) 30° (b) 60°
(c) 70° (d) 45°

AP EAMCET (21.09.2020) Shift-I

Ans. (d) : Given, $\frac{R}{2} = 200$ m, R = 400 m

Maximum height (H) = 100 m



$$\therefore \text{ Range (R)} = \frac{R}{2} + \frac{R}{2} = 200m + 200m = 400m$$

If θ be the direction of shot with respect to horizontal, then

$$R = \frac{u^2 \sin 2\theta}{g} \quad \text{and} \quad H = \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore \frac{R}{H} = \frac{\frac{u^2 \sin 2\theta}{g}}{\frac{u^2 \sin^2 \theta}{2g}} = \frac{2 \sin 2\theta}{\sin^2 \theta}$$

$$\frac{400}{100} = \frac{2 \times 2 \sin \theta . \cos \theta}{\sin^2 \theta} \qquad \{\because \sin 2\theta = 2 \sin \theta . \cos \theta\}$$

$$\Rightarrow \frac{4}{1} = 4 \cot \theta$$

$$\Rightarrow \cot \theta = 1 = \cot 45°$$

$$\Rightarrow \theta = 45°$$

325. When a player thrown a ball, it reaches the other player in 4 s. If the height of each player is 1.8 m, the maximum height attained by the ball above the ground is

(a) 19.4 m (b) 20.4 m
(c) 21.4 m (d) 22.4 m

AP EAMCET (18.09.2020) Shift-II

Ans. (c) : Given,

Each player Height (H) = 1.8 m

Time taken to reach the ball from one player to other player (T) = 4 sec

We know that,

$$T = \frac{2u \sin \theta}{g}$$

$$4 = \frac{2u \sin \theta}{g}$$

$$2g = u \sin \theta \qquad \text{..........(i)}$$

$$\text{Maximum height } (H_{max}) = \frac{u^2 \sin^2 \theta}{2g}$$

$$H_{max} = \frac{(u \sin \theta)^2}{2g}$$

$$H_{max} = \frac{(2g)^2}{2g} \quad \text{[From equation (i)]}$$

$$H_{max} = 2g = 2 \times 9.8$$

$$H_{max} = 19.6 \text{ m}$$

Maximum height attained by ball above the ground

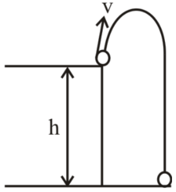
$$= H + H_{max} = 1.8 + 19.6 = 21.4 \text{ m}$$

326. A ball is projected upwards from a height h above the surface of the earth with velocity v. The time at which the ball strikes the ground is

(a) $\frac{v}{g}\left[1 + \sqrt{\frac{2gh}{v^2}}\right]$ (b) $\frac{v}{g}\left[1 - \sqrt{1 + \frac{2gh}{g}}\right]$
(c) $\frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right]$ (d) $\frac{v}{g}\left[1 + \sqrt{v^2 + \frac{2g}{v^2}}\right]$

AP EAMCET (17.09.2020) Shift-II

Ans. (c) : Given, $u_y = +v$, $a_y = -g$, $s_y = -h$



Now, from the second equation of motion-

$$\therefore \quad s_y = u_y t + \frac{1}{2} a_y t^2$$

$$-h = vt - \frac{1}{2} g t^2$$

$$\frac{1}{2} g t^2 - vt - h = 0$$

$$t = \frac{v \pm \sqrt{v^2 + 4 \frac{1}{2} gh}}{2 \times \frac{1}{2} g} \qquad \left\{ \begin{array}{l} \text{If } ax^2 + bx + c = 0 \\ \text{then. } x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a} \end{array} \right.$$

Taking positive sign,

$$t = \frac{v + \sqrt{v^2 + 2gh}}{g}$$

@apna_pdf

$$t = \frac{v}{g} + \frac{\sqrt{v^2 + 2gh}}{g}$$

$$t = \frac{v}{g} + \frac{\sqrt{v^2\left(1 + \frac{2gh}{v^2}\right)}}{g}$$

$$t = \frac{v}{g} + \frac{v}{g}\sqrt{1 + \frac{2gh}{v^2}}$$

$$t = \frac{v}{g}\left(1 + \sqrt{1 + \frac{2gh}{v^2}}\right)$$

327. A body is projected at an angle of 45° from a point on the ground at a distance of 30 m from the foot of a vertical pole of height 20 m. The body just crosses the top of the pole and strikes the ground at a distances from the foot of the pole on the other side of the pole. Then, s

(a) 20 m (b) 30 m

(c) 50 m (d) 60 m

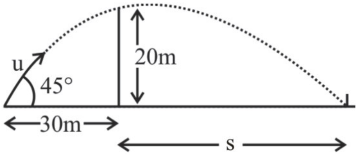
AP EAMCET (23.04.2019) Shift-I

Ans. (d) : Given data –

Angle of projection = 45°

Horizontal distance =30 m

Height of pole = 20 m



From the above figure –

$30 = ut \cos 45°$

$$ut = \frac{30}{\cos 45°} = 30\sqrt{2} \qquad ....(i)$$

And,

$$20 = ut \sin 45° - \frac{10}{2}t^2 \qquad (\because g = 10 \text{ m/s}^2)$$

$$20 = \frac{u}{\sqrt{2}}t - 5t^2$$

$$20 = \frac{30\sqrt{2}}{\sqrt{2}} - 5t^2 \qquad \{\therefore ut = 30\sqrt{2}\}$$

$5t^2 = 10$

$t^2 = 2$

$t = \sqrt{2}$

Put the value $t = \sqrt{2}$ in equation (i)

$ut = 30\sqrt{2}$

$u \times \sqrt{2} = 30\sqrt{2}$

u = 30 m/sec

Then, $$R = \frac{u^2 \sin 2\theta}{g} = \frac{30 \times 30 \times \sin 90°}{10} = 90 \text{ m}$$

∴ Distance between pole and the point at which body strike on the ground.

s = 90 – 30 = 60 m

328. A bullet fired from a gun falls at a distance half of its maximum range. The angle of projection of the bullet is

(a) 45° (b) 60°

(c) 30° (d) 15°

AP EAMCET (23.04.2019) Shift-I

Ans. (d) : As we know that –

$$\text{Range (R)} = \frac{u^2 \sin 2\theta}{g}$$

Range is maximum, when θ is equal to 45°.

So,

$$R_{max} = \frac{u^2}{g}$$

Given,

$$R = \frac{R_{max}}{2}$$

$$\frac{u^2 \sin 2\theta}{g} = \frac{u^2}{2g}$$

$$\sin 2\theta = \frac{1}{2}$$

$\sin 2\theta = \sin 30°$

$2\theta = 30°$

$\theta = 15°$

329. A body is projected at an angle of 60° with the horizontal such that the vertical component of its initial velocity is 40 ms^{-1}. The magnitude of velocity of the projectile at one quarter of its time of flight is nearly,

(Acceleration due to gravity, g = 10 ms^{-2})

(a) 3.54 ms^{-1} (b) 35.40 ms^{-1}

(c) 30.54 ms^{-1} (d) 34.5 ms^{-1}

AP EAMCET (21.04.2019) Shift-II

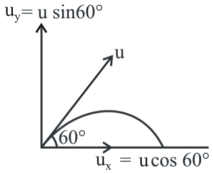
Ans. (c) : Given that, initial velocity $(u_y) = 40\text{ms}^{-1}$

Vertical component of velocity

$u \sin 60° = 40$

$$\frac{\sqrt{3}}{2}u = 40$$

$$u = \frac{80}{\sqrt{3}} \text{ms}^{-1}$$



$$\because \quad \text{Time of flight (T)} = \frac{2u \sin\theta}{g}$$

$$T = \frac{2 \times \frac{80}{\sqrt{3}} \sin 60°}{10}$$

$$T = 2 \times \frac{80}{\sqrt{3}} \times \frac{\sqrt{3}}{2} \times \frac{1}{10}, \quad T = 8 \text{ sec}$$

@apna_pdf

The magnitude of velocity of the projectile at one quarter of its time of flight

$$T_q = \frac{T}{4} = \frac{8}{4}$$

$$T_q = 2 \text{ sec}$$

$$u_x = u \cos 60^o$$

$$u_x = \frac{80}{\sqrt{3}} \times \frac{1}{2}$$

$$u_x = \frac{40}{\sqrt{3}}$$

From first equation of the motion

$$v_y = u_y - gT_q \qquad (T_q = 2 \text{ sec})$$

$$v_y = 40 - 10 \times 2$$

$$v_y = 20 \text{ ms}^{-1}$$

Hence, at $T_q = \frac{T}{4}$, magnitude of velocity of projectile

$$v = \sqrt{u_x^2 + v_y^2}$$

$$= \sqrt{\left(\frac{40}{\sqrt{3}}\right)^2 + (20)^2}$$

$$v \approx 30.54 \text{ ms}^{-1}$$

330. If the maximum height and range of a projectile are 3 m and 4 m respectively, then the velocity of the projectile is (Take, g = 10 ms^{-2})

(a) $20\sqrt{\frac{6}{5}}\text{ms}^{-1}$ (b) $10\sqrt{\frac{3}{2}}\text{ms}^{-1}$

(c) $10\sqrt{\frac{2}{3}}\text{ms}^{-1}$ (d) $20\sqrt{\frac{5}{6}}\text{ms}^{-1}$

AP EAMCET (21.04.2019) Shift-I

Ans. (c) : Given, maximum height (H) = 3 m

Range (R) = 4m

We know,

Maximum height (H) $= \frac{u^2 \sin^2\theta}{2g}$

$$3 = \frac{u^2 \sin^2\theta}{2g} \qquad \text{......(i)}$$

and Range (R) $= \frac{u^2 \sin 2\theta}{g}$

$$4 = \frac{u^2 \sin 2\theta}{g} \qquad \text{......(ii)}$$

The ratio of maximum height and range is–

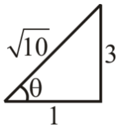
$$\frac{H}{R} = \frac{\frac{u^2 \sin^2\theta}{2g}}{\frac{u^2 \sin 2\theta}{g}}$$

$$\frac{3}{4} = \frac{\sin^2\theta}{2\sin 2\theta}$$

$$3 \sin 2\theta = 2\sin^2\theta$$

$$\frac{3 \times 2\sin\theta.\cos\theta}{\sin\theta.\sin\theta} = 2 \quad (\because \sin 2\theta = 2\sin\theta \cos\theta)$$

$$\tan\theta = 3$$



So, $\sin\theta = \frac{3}{\sqrt{10}}$ ...(iii)

Putting the value of $\sin\theta = \frac{3}{\sqrt{10}}$ in equation (i)

$$3 \times 2 \times 10 = u^2 \sin^2\theta$$

$$3 \times 2 \times 10 = u^2 \times \left(\frac{3}{\sqrt{10}}\right)^2$$

$$u^2 = \left(\frac{\sqrt{10}}{3}\right)^2 \times 3 \times 2 \times 10$$

$$u^2 = \frac{100 \times 2}{3}$$

$$u = 10\sqrt{\frac{2}{3}}$$

So, the velocity of the projectile is $10\sqrt{2/3}$ m/s

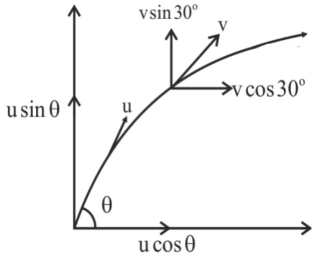
331. Two boys conducted experiments on the projectile motion with stopwatch and noted some readings. As one boy throws a stone in air at the same angle with the horizontal, the other boy observes that after 4s, the stone is moving at an angle 30° to the horizontal and after another 2s it is travelling horizontally. The magnitude of the initial velocity of the stone is (Acceleration due to gravity, g = 10 ms^{-2}.)

(a) $40\sqrt{3}\text{ ms}^{-1}$ (b) $20\sqrt{3}\text{ ms}^{-1}$

(c) $10\sqrt{3}\text{ ms}^{-1}$ (d) $50\sqrt{3}\text{ ms}^{-1}$

AP EAMCET (20.04.2019) Shift-II

Ans. (a) : Given, g = 10 m/s^2, θ = 30°, t = 4s,



$$\because \quad u\cos\theta = v\cos 30^o \qquad \text{....(i)}$$

$$v\sin 30^o = u\sin\theta - gt \qquad \text{....(ii)}$$

From equation (i) and (ii)

$$\tan 30^\circ = \frac{u\sin\theta - g \times 4}{u\cos\theta} \qquad \text{...(iii)}$$

Total time to reach the stone at horizontal surface,

$$t = 2 + 4 = 6 \text{ sec}$$

After t = 6 sec, θ = 0°

@apna_pdf

$$\tan 0° = \frac{u\sin\theta - g\times 6}{u\cos 0°}$$

$u\sin\theta - g(6) = 0$

$u\sin\theta = 10\times 6$

$u\sin\theta = 60$

From equation (iii), at t = 4s,

$$u\cos\theta = \frac{60-10\times 4}{\tan 30°}$$

$$u\cos\theta = 20\sqrt{3} \qquad \ldots(iv)$$

Now magnitude of initial velocity,

$$u = \sqrt{(u\sin\theta)^2 + (u\cos\theta)^2}$$

$$u = \sqrt{(60)^2 + (20\sqrt{3})^2}$$

$$u = \sqrt{3600+1200} = \sqrt{4800}$$

$$u = 40\sqrt{3}\,m/s$$

332. A projectile is given an initial velocity of $(\hat{i}+2\hat{j})\,ms^{-1}$. The equation of its path is (g = 10 ms^{-2})

(a) $y = 2x - 5x^2$ (b) $y = x - 5x^2$

(c) $4y = 2x - 5x^2$ (d) $y = 2x - 25x^2$

AP EAMCET (22.04.2018) Shift-II

Ans. (a) : Given that, $u = \hat{i} + 2\hat{j}$

$$\vec{u} = u_x\hat{i} + u_y\hat{j}$$

$$u_x = u\cos\theta = 1$$

$$u_y = u\sin\theta = 2$$

$$\because \quad \tan\theta = \frac{u\sin\theta}{u\cos\theta} = \frac{2}{1}$$

From, $$y = x\tan\theta - \frac{1}{2}\frac{gx^2}{u_x^2}$$

$$y = x\times 2 - \frac{1}{2}\times\frac{10x^2}{1}$$

$$y = 2x - 5x^2$$

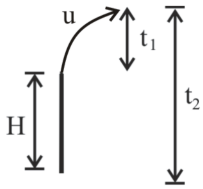
333. A body is projected vertically upwards with a velocity u from the top of a tower. Time taken by it to reach the ground is n times, then the time taken by it to reach the highest point in its path. Height of the tower is

(a) $\frac{nu^2(n-1)}{2g}$ (b) $\frac{nu^2(n-2)}{g}$

(c) $\frac{nu^2(n-2)}{2g}$ (d) $\frac{u^2(n+1)}{2g}$

AP EAMCET (23.04.2018) Shift-1

Ans. (c) :



Let, the time taken to reach the maximum height, when thrown vertically upwards.

$$t_1 = \frac{u}{g}$$

If t_2 be the time to hit the ground, then

$$t_2 = nt_1 = \frac{nu}{g}$$

From equation of motion

$$s = ut + \frac{1}{2}at^2$$

$$-H = u.n\left(\frac{u}{g}\right) - \frac{1}{2}g\frac{n^2.u^2}{g^2} \qquad [s = -H, t = t_2 = nt_1]$$

$$-H = \frac{nu^2}{g} - \frac{n^2u^2}{2g}$$

$$2gH = nu^2(n-2)$$

$$H = \frac{nu^2(n-2)}{2g}$$

334. Assertion (A): The velocity of a projectile at a point on its trajectory is equal to the slope at that point.

Reason (R): The velocity vector at a point is always along the tangent to the trajectory at that point.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

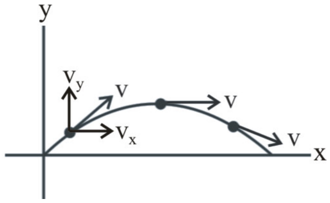
AP EAMCET (22.04.2018) Shift-1

Ans. (d) : We know,

Trajectory of projectile

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

$$\because \quad \frac{dy}{dx} = \text{Slope} = \frac{dy/dt}{dx/dt} = \frac{v_y}{v_x}$$



Here, assertion is incorrect but reason is correct, the velocity vector at a point is always along the tangent to the trajectory is true.

335. A body is projected from the ground at an angle of $\tan^{-1}\left(\frac{8}{7}\right)$ with the horizontal. The ratio of the maximum height attained by it to its range is

(a) 8 : 7 (b) 4 : 7

(c) 2 : 7 (d) 1 : 7

AP EAMCET (22.04.2018) Shift-1

@apna_pdf

Ans. (c) : Given,

$$\theta = \tan^{-1}\left(\frac{8}{7}\right)$$

$$\tan\theta = \frac{8}{7}$$

We know,

$$\text{Maximum height (H)} = \frac{u^2\sin^2\theta}{2g}$$

and $$\text{Range (R)} = \frac{u^2\sin 2\theta}{g}$$

Then,

$$\therefore \quad \frac{H}{R} = \frac{\frac{u^2\sin^2\theta}{2g}}{\frac{u^2\sin 2\theta}{g}} = \frac{\tan\theta}{4}$$

$$\frac{H}{R} = \frac{\tan\theta}{4} = \frac{8}{4\times 7}$$

$$\frac{H}{R} = \frac{2}{7}$$

or $$H : R = 2 : 7$$

336. The equation of a projectile is $y = \sqrt{3}x - \frac{gx^2}{2}$ The angle of projection is given by

(a) $\tan\theta = \frac{1}{\sqrt{3}}$ (b) $\tan\theta = \sqrt{3}$

(c) $\frac{\pi}{2}$ (d) zero

BITSAT-2020

Ans. (b) : The equation of projectile is

$$y = \sqrt{3}x - \frac{gx^2}{2} \quad ....(i)$$

We know,
Equation of a projectile is

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \quad ..... (ii)$$

By comparing the both equation we get–

$$x\tan\theta = \sqrt{3}\,x$$

$$\tan\theta = \sqrt{3}$$

337. A stone is thrown with a velocity u making an angle θ with the horizontal. The horizontal distance covered by its fall to ground is maximum when the angle θ is equal to

(a) 0° (b) 30° (c) 45° (d) 90°

BITSAT-2019

Ans. (c) : We know that, Range (R) = $\frac{u^2\sin 2\theta}{g}$

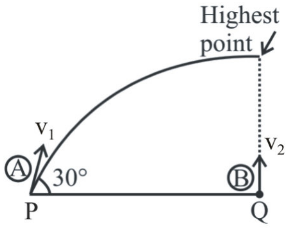
For maximum range, $\sin 2\theta = 1$

$$\sin 2\theta = \sin 90^\circ$$

$$2\theta = 90^\circ$$

$$\theta = 45^\circ$$

338. A projectile A is thrown at an angle of 30° to the horizontal from point P. At the same time, another projectile B is thrown with velocity v_2 upwards from the point Q vertically below the highest point. For B to collide with A, $\frac{v_2}{v_1}$ should be

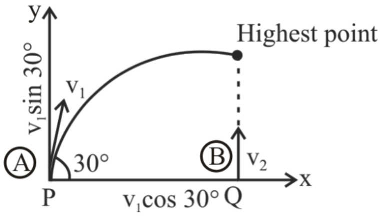


(a) 1 (b) 2

(c) $\frac{1}{2}$ (d) 4

BITSAT-2020

Ans. (c) :



If projectile B collides with A, then their vertical velocity should be same.

$$v_1\sin 30^\circ = v_2$$

$$\frac{v_2}{v_1} = \sin 30^\circ \Rightarrow \frac{v_2}{v_1} = \frac{1}{2}$$

339. A stone is projected from the ground with velocity 25 m/s. Two seconds later, it just clears a wall 5m high. The angle of projection of the stone is ($g = 10\text{m/sec}^2$)

(a) 30° (b) 45°
(c) 50.2° (d) 60°

BITSAT-2007

Ans. (a) : Given,

$$h = 5\text{ m},\ t = 2\text{s},\ u_y = 25\sin\theta$$

After 2 sec it clear a wall of 5m high means its height from ground is nearly 5m.

$$\text{Height, } h = u_y t - \frac{gt^2}{2}$$

$$5 = 25\sin\theta \times 2 - \frac{1}{2}\times 10\times(2)^2$$

$$5 + 20 = 50\sin\theta$$

$$\sin\theta = 1/2$$

$$\theta = 30^\circ$$

340. A cannon ball has the same range R on horizontal plane for two angles of projection θ and β, then

(a) $\theta = 180^\circ - \beta$ (b) $\theta = 90^\circ - \beta$
(c) $\theta = 45^\circ + \beta$ (d) $\theta = 60^\circ + \beta$

BITSAT-2008

@apna_pdf

Ans. (b) : A cannon ball has the same range R on horizontal plane for two angles of projection θ and β, then

$$\theta + \beta = 90°$$

$$\boxed{\theta = 90 - \beta}$$

341. A projectile projected at an angle 30° from the horizontal has a range R. If the angle of projection at the same initial velocity be 60°, then the range will be –

(a) R (b) R/2

(c) 2R (d) R^2

BITSAT-2009

Ans. (a) : Range of projectile is given by,

$$R = \frac{u^2 \sin 2\theta}{g}$$

Case 1: $\theta_1 = 30°$

$$R_1 = \frac{u^2 \sin 60°}{g} = \frac{u^2}{g} \times \frac{\sqrt{3}}{2}$$

Case 2 : $\theta_2 = 60°$

$$R_2 = \frac{u^2 \sin 120°}{g} = \frac{u^2}{g} \cos 30° = \frac{u^2}{g} \times \frac{\sqrt{3}}{2}$$

$\therefore$ $R_1 = R_2$

342. Two projectiles A and B are thrown with the same speed but angles are 40° and 50° with the horizontal. Then

(a) A will fall earlier

(b) B will fall earlier

(c) Both will fall at the same time

(d) None of these

BITSAT- 2010

Ans. (a) : Time of flight $(T) = \frac{2u \sin\theta}{g}$

Velocity of projectile A & B are same

So, $T \propto \sin\theta$

$\theta_A < \theta_B$

Hence, $T_A < T_B$

So, A will fall earlier

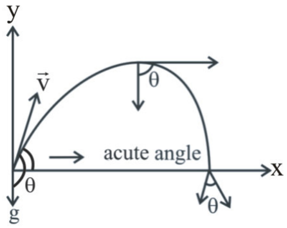
343. A body is projected, making an acute angle with the horizontal. If angle between velocity $\vec{v}$ and acceleration $\vec{g}$ is θ, then

(a) θ = 90° (b) θ = 0°

(c) 90° < θ < 0° (d) 0° < θ < 180°

BITSAT-2013

Ans. (d) :



Here, velocity is acting upward when projectile is going upward and acceleration is downward. As per the question, the angle between $\vec{v}$ and $\vec{g}$ is θ, then θ should be more than 0° but less than 180°

So, $0° < \theta° < 180°$

344. The range of the particle when launched at an angle of 15° with the horizontal is 1.5 km. What is the range of the projectile when launched at an angle of 45° to the horizontal.

(a) 1.5 km (b) 3.0 km

(c) 6.0 km (d) 0.75 km

BITSAT-2012

Ans. (b) : Given that,

$R_1 = 1.5$ km, $\theta = 15°$

I

I^{st} Case-

When a particle throw at an angle θ then,

$$R_1 = \frac{u^2 \sin 2\theta}{g}$$

$$1.5 = \frac{u^2 \sin(2\times 15°)}{g} = \frac{u^2 \sin 30°}{g}$$

$$1.5 = \frac{u^2}{2g}$$

$$\frac{u^2}{g} = 3\text{km}$$

II^{nd} Case-

Horizontal range for angle of projection 45° will be:

$$R_2 = \frac{u^2 \sin(2\times 45°)}{g} = \frac{u^2}{g}\sin 90°$$

$$R_2 = \frac{u^2}{g} = 3\text{km} \quad \left[\because \frac{u^2}{g} = 3\text{km}\right]$$

So, the range of projectile is 3 km.

345. The position of a projectile launched from the origin at t = 0 is given by $\vec{r} = (40\hat{i} + 50\hat{j})$ m at t = 2s. If the projectile was launched at an angle θ from the horizontal, then θ is (take g = 10 ms^{-2})

(a) $\tan^{-1}\frac{2}{3}$ (b) $\tan^{-1}\frac{3}{2}$

(c) $\tan^{-1}\frac{7}{4}$ (d) $\tan^{-1}\frac{4}{5}$

BITSAT - 2015

Ans. (c) : We know that horizontal component of projected velocity remains constant

So, according to question -

Horizontal velocity $(u_x) = \frac{40-0}{2-0} = 20$ m/s

And, initial vertical velocity (u_y)

$$s_y = u_y t + \frac{1}{2}at^2$$

$$50 = u_y(2) - \frac{1}{2}(10)(2)^2$$

@apna_pdf

$$u_y = \frac{70}{2} = 35\ \text{m/s}$$

$$\therefore\ \tan\theta = \frac{u_y}{u_x} = \frac{35}{20} = \frac{7}{4}$$

$$\theta = \tan^{-1}\frac{7}{4}$$

346. The equation of trajectory of projectile is given by $y = \frac{x}{\sqrt{3}} - \frac{gx^2}{20}$, where x and y are in metre. The maximum range of the projectile is

(a) $\frac{8}{3}$m (b) $\frac{4}{3}$m

(c) $\frac{3}{4}$m (d) $\frac{3}{8}$m

BITSAT - 2015

Ans. (b) : The equation of trajectory of projectile is:-

$$y = \frac{x}{\sqrt{3}} - \frac{gx^2}{20} \qquad \ldots.(i)$$

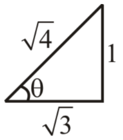
$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

Where, y = vertical component

x = horizontal component

u = initial velocity

Comparing the equation (i) with equation of trajectory of a projectile



$$\tan\theta = \frac{1}{\sqrt{3}},\ \theta = 30°$$

$$2u^2\cos^2\theta = 20$$

$$u^2 = \frac{20}{2\cos^2\theta} = \frac{40}{3}$$

Range, $R = \frac{u^2\sin 2\theta}{g}$

For, R_{max} at $\theta = 45°$

$\because$ $R_{max} = \frac{u^2\sin 90°}{g}$

$$R_{max} = \frac{u^2}{g} = \frac{40}{3\times10} \Rightarrow R_{max} = \frac{4}{3}\text{m}$$

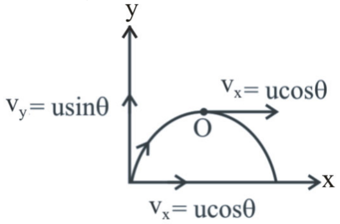
347. A projectile is fired with a velocity u making an angle θ with the horizontal. What is the magnitude of change in velocity when it is at the highest point

(a) u cos θ (b) u

(c) u sin θ (d) u cos θ – u

BITSAT - 2014

Ans. (c) : Given that,



Initial velocity of projectile-

$$\vec{u} = u\cos\theta\,\hat{i} + u\sin\theta\,\hat{j}$$

$\because$ At the highest point only horizontal velocity is present

$$\vec{v} = u\cos\theta\,\hat{i} + 0\times\hat{j} = u\cos\theta\,\hat{i}$$

Therefore, the change in velocity is

$$\Delta\vec{v} = \vec{u} - \vec{v}$$

$$\Delta\vec{v} = u\cos\theta\,\hat{i} + u\sin\theta\,\hat{j} - u\cos\theta\,\hat{i}$$

$$\Delta\vec{v} = u\sin\theta\hat{j}$$

$$|\Delta\vec{v}| = u\sin\theta$$

348. Two projectiles A and B thrown with speeds in the ratio 1: $\sqrt{2}$ acquired the same heights. If A is thrown at an angle of 45° with the horizontal, the angle of projection of B will be

(a) 0° (b) 60°

(c) 30° (d) 45°

BITSAT- 2017

Ans. (c) : Given, $\frac{v_A}{v_B} = \frac{1}{\sqrt{2}}$

The expression for the height attained by projectile is given as-

$$h = \frac{v^2\sin^2\alpha}{2g} \qquad \begin{bmatrix} v = \text{Speed} \\ \alpha = \text{Angle} \end{bmatrix}$$

Now, both A and B have same heights, therefore

$$h_A = h_B$$

$$\frac{v_A^2\sin^2 45°}{2g} = \frac{v_B^2\sin^2\phi}{2g}$$

$$v_A^2\sin^2 45° = v_B^2\sin^2\phi$$

$$\frac{v_A^2}{v_B^2}\sin^2 45° = \sin^2\phi$$

$$\sin^2\phi = \left(\frac{v_A}{v_B}\right)^2 \times \left(\frac{1}{\sqrt{2}}\right)^2 \Rightarrow \sin^2\phi = \left(\frac{1}{\sqrt{2}}\right)^2 \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$\sin^2\phi = \frac{1}{4}$$

$$\sin\phi = \frac{1}{2} = \sin 30°$$

$$\phi = 30°$$

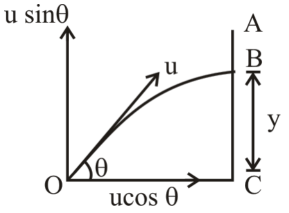
349. A hunter aims his gun and fires a bullet directly at a monkey on a tree. At the instant the bullet leaves the barrel of the gun, the monkey drops. Pick the correct statement regarding the situation.

@apna_pdf

(a) The bullet will never hit the monkey
(b) The bullet will always hit the monkey
(c) The bullet may or may not hit the monkey
(d) Can't be predicted

BITSAT- 2018

Ans. (b) :



This situation is clearly an example of projectile motion in which projectile motion of bullet is projected by aiming the monkey sitting on the tree. The monkey will die providing that at the time of firing, monkey was at the same horizontal level as hunter. It will happen because, as the bullet was fired, its downward velocity was same as monkey. So, both will travel same distance downwards and bullet will strike monkey.

350. A projectile thrown at an angle of 30° with the horizontal has a range R_1 and attains a maximum height h_1. Another projectile thrown with the same speed, at an angle of 30° with the vertical has a range R_2 and attains a maximum height h_2, then

(a) $R_2=R_1, h_1=h_2$
(b) $R_2=2R_1, h_1=3h_2$
(c) $R_2=R_1, h_2=3h_1$
(d) $R_2=3R_1, h_1=3h_2$

CG PET -2018

Ans. (c) :

Height of projectile (H) $= \dfrac{u^2\sin^2\theta}{2g}$ ...(i)

Range, $R = \dfrac{u^2\sin 2\theta}{g}$ ...(ii)

The angle of projection of the two projectiles are 30° and (90° – 30°) = 60°

Therefore, $R_1 = \dfrac{u^2\sin(2\times 30^\circ)}{g} = \dfrac{\sqrt{3}}{2}\dfrac{u^2}{g}$

$$R_2 = \frac{u^2\sin(2\times 60^\circ)}{g} = \frac{\sqrt{3}}{2}\frac{u^2}{g}$$

And,

Height, $h_1 = \dfrac{u^2\sin^2 30^\circ}{2g} = \dfrac{1}{4}\left[\dfrac{u^2}{2g}\right]$

$$h_2 = \frac{u^2\sin^2 60^\circ}{2g} = \frac{3}{4}\left[\frac{u^2}{2g}\right]$$

Thus,

$$R_2 = R_1$$
$$h_2 = 3h_1$$

351. Four projectiles are thrown with the same initial speed making angles 27°, 39°, 43°, 51°with the horizontal. The range of projectiles will be larges for the projectile fired at angle

(a) 27°
(b) 26°
(c) 43°
(d) 51°

CG PET- 2015
MANIPAL-2020

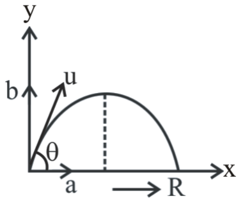
Ans. (c) : Range of a projectile is maximum at angle of projection 45°.
The nearest value is 43°. Thus among given values of angles of projection, range will be maximum for 43°

352. A projectile is thrown with an initial velocity of $\vec{u} = (a\hat{i} + b\hat{j})$ m/s. If the range of the projectile is double the maximum height reached by it, then

(a) a= 2b
(b) b=2a
(c) a=b
(d) None of these

CG PET- 2014

Ans. (b) : Given that, $\vec{u} = (a\hat{i} + b\hat{j})$ m/s, a = ucosθ, b = usinθ



According to question:

R = 2h (Given)

$$\frac{u^2\sin 2\theta}{g} = \frac{2u^2\sin^2\theta}{2g}$$

$$\sin 2\theta = \sin^2\theta$$
$$2\sin\theta\cos\theta = \sin^2\theta$$
$$2\cos\theta = \sin\theta$$
$$\tan\theta = 2$$

Now, $\vec{u} = a\hat{i} + b\hat{j}$

$$\tan\theta = \frac{b}{a}$$

So, $\dfrac{b}{a} = 2$

$$b = 2a$$

353. A ball is projected at an angle θ upwards from horizontal. The true statement is

(a) at each point of flight vertical component of momentum remains constant
(b) at each point of flight horizontal component of momentum remains constant
(c) at the highest point of flight, potential energy is minimum
(d) at the highest point of flight, kinetic energy is zero

CG PET- 2011

Ans. (b) : A ball is projected at an angle θ upward from horizontal. Then at each point of flight horizontal component of momentum remains constant.

@apna_pdf

354. A body of mass m is thrown upwards at an angle θ with the horizontal with velocity v. While rising up the velocity of the mass after t seconds will be

(a) $\sqrt{(v\cos\theta)^2+(v\sin\theta)^2}$

(b) $\sqrt{(v\cos\theta-v\sin\theta)^2-gt}$

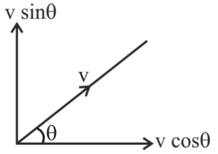
(c) $\sqrt{v^2+g^2t^2-2v\sin\theta gt}$

(d) $\sqrt{v^2+g^2+t^2-(2v\cos\theta)gt}$

CG PET- 2008

Ans. (c) : $v_y = v\sin\theta - gt$ (vertical component)

$v_x = v\cos\theta$ (horizontal component)



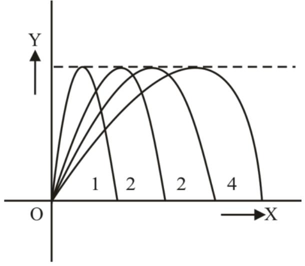
Velocity of running mass after t sec will be:

$$v_t=\sqrt{(v\cos\theta)^2+(v\sin\theta-gt)^2}$$

$$v_t=\sqrt{v^2\cos^2\theta+v^2\sin^2\theta+(gt)^2-2v\sin\theta gt}$$

$$v_t=\sqrt{v^2+g^2t^2-2v\sin\theta gt}$$

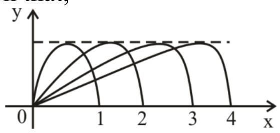
355. Figure shows four paths for a kicked football. Ignoring the effects of air on the flight, rank the paths according to initial horizontal velocity component, highest first



(a) 1,2,3,4
(b) 2,3,4,1
(c) 3,4,1,2
(d) 4,3,2,1

CG PET- 2007

Ans. (d) : Given that,



We know that,

Range, $R=\dfrac{u^2\sin2\theta}{g}$

$R\propto u^2$

∴ Horizontal range ∝ horizontal component of velocity.

Horizontal range-

$R_4 > R_3 > R_2 > R_1$

Therefore,

Horizontal velocity component

$(v_H)_4 > (v_H)_3 > (v_H)_2 > (v_H)_1$

356. A particle of mass m is projected with a velocity v making angle of 45º with the horizontal. The magnitude of angular momentum of the projectile about the axis of projection when the particle is at maximum height

(a) zero
(b) $\dfrac{mv^3}{4\sqrt{2}g}$
(c) $\dfrac{mv^3}{\sqrt{2}g}$
(d) $\dfrac{mv^2}{2g}$

CG PET- 2006

Ans. (b) : Given that,

θ = 45°

Maximum height attained by the projectile.

$$H=\frac{v^2\sin^2\theta}{2g}$$

$$\therefore\quad H=\frac{v^2\sin^2 45^o}{2g}=\frac{v^2}{2g}\times\left(\frac{1}{\sqrt{2}}\right)^2=\frac{v^2}{4g}$$

Velocity at maximum height $=v\cos 45^o=\dfrac{v}{\sqrt{2}}$

Angular momentum at maximum height = mvH

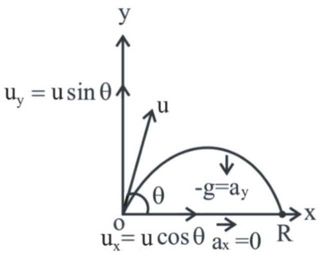
$$=m\times\frac{v}{\sqrt{2}}\times\frac{v^2}{4g}=\frac{mv^3}{4\sqrt{2}g}$$

357. When a body is thrown with a velocity u making an angle θ with the horizontal plane the maximum distance covered by it in horizontal direction is

(a) $\dfrac{u^2\sin\theta}{g}$
(b) $\dfrac{u^2\sin2\theta}{2g}$
(c) $\dfrac{u^2\sin2\theta}{g}$
(d) $\dfrac{u^2\cos2\theta}{g}$

CG PET- 2005

Ans. (c) :



Distance travelled in horizontal direction = Horizontal component of velocity × time period

$$R=u\cos\theta\times\frac{2u\sin\theta}{g}$$

$$R=u^2\times\frac{2\sin\theta\cos\theta}{g}$$

$$R=\frac{u^2\sin2\theta}{g}$$

@apna_pdf

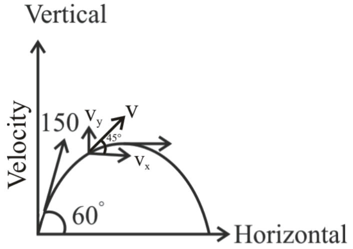
358. A projectile is thrown in upward direction making an angle of 60º with the horizontal direction with a velocity of 150 ms^{-1}. Then, the time after which its inclination with horizontal is 45º, is

(a) $15\left(\sqrt{3}-1\right)s$ (b) $15\left(\sqrt{3}+1\right)s$

(c) $7.5\left(\sqrt{3}-1\right)s$ (d) $7.5\left(\sqrt{3}+1\right)s$

Manipal UGET-2015
JIPMER-2011

Ans. (c) : Given that, initial velocity (u) = 150 ms^{-1}
Initial horizontal component = u_x



Horizontal velocity at angle 45° = Horizontal velocity at angle 60°

$$v_x = 150\cos 60°$$

$$v \times \cos 45° = 150 \times \frac{1}{2}$$

$$v \times \frac{1}{\sqrt{2}} = 75$$

$$v = 75\sqrt{2}$$

Vertical component $u_y = u\sin 60°$

$$= 150 \times \frac{\sqrt{3}}{2} = 75\sqrt{3}\ \text{m/s}$$

Vertical component at 45°

$$v_y = v\sin 45°$$

$$v_y = 75\sqrt{2}\times\frac{1}{\sqrt{2}} = 75$$

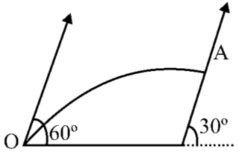
But first law of motion, v = u – gt

Then, $v_y = u_y - gt \Rightarrow t = \dfrac{u_y - v_y}{g}$

$$t = \frac{75\times\sqrt{3}-75}{10} = \frac{75(\sqrt{3}-1)}{10}\ s$$

$$t = 7.5\left(\sqrt{3}-1\right)s$$

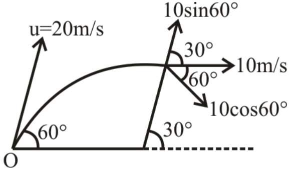
359. A ball is projected from the point O with velocity 20 m/s at an angle of 60º with horizontal as shown in the figure. At highest point of its trajectory, it strikes a smooth plane of inclination 30º at point A. The collision is perfectly inelastic. The maximum height from the ground attained by the ball is



(a) 18.75 m (b) 15 m
(c) 22.5 m (d) 20.25 m

Manipal UGET-2015

Ans. (a) : Given, u = 20 m/s, g = 10 m/s^2



Speed of ball before collision is –

$$v = u\cos\theta$$

$$v = u\cos 60° = 20\times\frac{1}{2} = 10\ \text{m/s}$$

Highest point of its trajectory = h_1

$$h_1 = \frac{u^2\sin^2 60°}{2g}$$

Because collision is perfectly inelastic so, the ball does not bounce and starts moving along the plane.

$$v_1 = v\cos\theta$$

$$v_1 = v\cos 30° = 10\times\frac{\sqrt{3}}{2} = 5\sqrt{3}$$

Let, mass of ball = m kg
By energy conservation, K.E = potential energy

$$\frac{1}{2}mv_1^2 = mgh_2$$

$$h_2 = \frac{v_1^2}{2g}$$

∴ Maximum height attained by ball (H) = $h_1 + h_2$

$$H = \frac{u^2\sin^2 60°}{2g} + \frac{v_1^2}{2g}$$

$$H = \frac{(20)^2\times\left(\frac{\sqrt{3}}{2}\right)^2}{2\times10} + \frac{\left(5\sqrt{3}\right)^2}{2\times10} = \frac{400\times\frac{3}{4}}{20} + \frac{75}{20}$$

$$H = \frac{300}{20} + \frac{75}{20} = \frac{375}{20} = 18.75\ \text{m}$$

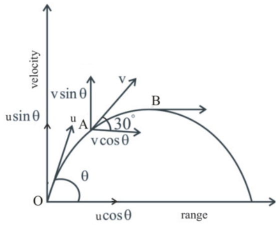
360. Two seconds after projection, a projectile is travelling in a direction inclined at 30º to the horizontal. After one more sec, it is travelling horizontally, the magnitude and direction of its velocity are

(a) $2\sqrt{20}\ \text{m/s}, 60º$ (b) $20\sqrt{3}\ \text{m/s}, 60º$

(c) $6\sqrt{40}\ \text{m/s}, 60º$ (d) $40\sqrt{6}\ \text{m/s}, 30º$

Manipal UGET-2014

Ans. (b) :



@apna_pdf

Total time of ascent = 3sec

$$t=\frac{u\sin\theta}{g}=3$$

$u\sin\theta = 3g$

$u\sin\theta = 30$ .....(i)

Using first law of motion in vertical direction from A to B–

$v_y = u_y - gt$

$v\sin30° = u\sin\theta - g\times 2$ $(\because t = 2\text{ sec})$

$$\frac{v}{2}=u\sin\theta-2g \quad ...(ii)$$

After t = 3 second projectile is travelling horizontally that is it reach highest point B.

$$t=\frac{u\sin\theta}{g}$$

$$3=\frac{u\sin\theta}{g}$$

$3g = u\sin\theta$

Putting value of u sinθ in equation (ii), we get –

$$\frac{v}{2}=3g-2g$$

$v = 2g = 2 \times 10 = 20$ m/s

$v = 20$ m/s

$\because$ $u\cos\theta = v\cos30°$

$$u\cos\theta = 20\times\frac{\sqrt{3}}{2}=10\sqrt{3} \quad .....(iii)$$

Squaring equation (i) and (iii), we get–

$u^2(\sin^2\theta+\cos^2\theta) = (30)^2 + (10\sqrt{3})^2$

$u^2 = 900 + 300 = 1200$

$u = 20\sqrt{3}\text{ m/sec}$

And, $$\tan\theta=\frac{30}{10\sqrt{3}}=\frac{3}{\sqrt{3}}=\sqrt{3}$$

$\theta = 60°$

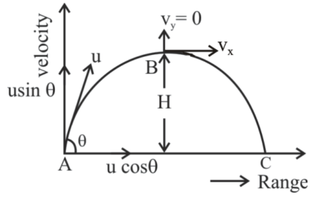
361. A stone is thrown at an angle θ to be horizontal reaches a maximum height H. Then the time of flight of stone will be

(a) $\sqrt{\frac{2H}{g}}$ (b) $2\sqrt{\frac{2H}{g}}$

(c) $\frac{2\sqrt{2H\sin\theta}}{g}$ (d) $\frac{\sqrt{2H\sin\theta}}{g}$

Manipal UGET-2010
BCECE - 2004
AP EAMCET (MEDICAL) - 1998

Ans. (b) : Given, maximum height = H



Let stone is thrown with initial velocity u m/s at an angle = θ, t is time to reach maximum height.

Vertical velocity at point A $(u_y) = u\sin\theta$

Vertical velocity at point B $(v_y) = 0$

Using first law of motion in vertical direction from A to B

$\because$ $v_y = u_y - gt$

$0 = u\sin\theta - gt$

$gt = u\sin\theta$ .....(i)

And, $$H = u_y t - \frac{1}{2}gt^2$$

$$H = (u\sin\theta)t - \frac{1}{2}gt^2 \quad .....(ii)$$

Putting value of u sinθ from equation (i) to in equation (ii), we get–

$$H = (gt)t - \frac{1}{2}gt^2$$

$$H = gt^2 - \frac{1}{2}gt^2 = \frac{1}{2}gt^2$$

$$t=\sqrt{\frac{2H}{g}}$$

Time take to reach maximum height = time take to reach ground from maximum height

The time of flight of stone $= 2t = 2\sqrt{\frac{2H}{g}}$

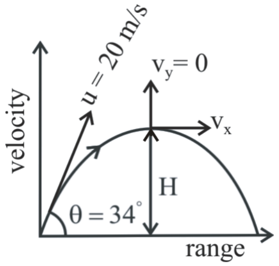
362. A 1.5 kg ball is shot upward at an angle of 34° to the horizontal with an initial speed of 20 m/s, then maximum height of the ball, reaches is (use cos 34° = 0.83 or sin 34° = 0.56)

(a) 6.3 m (b) 9.4 m

(c) 13.8 m (d) 11.2 m

TS-EAMCET-07.05.2018, Shift-1

Ans. (a) : Given, mass of ball (m) = 1.5 kg, initial velocity (u) = 20 m/s, maximum height (H) = ?



$$\text{Maximum height (H)} = \frac{u^2\sin^2\theta}{2g}$$

$$H=\frac{(20)^2\times\sin^2 34°}{2\times10}=\frac{400\times(0.56)^2}{20}$$

$$H=\frac{125.44}{20}=6.27=6.3\text{ m}$$

363. A small ball is thrown at an angle 45° to the horizontal with an initial velocity of $2\sqrt{2}$m/s. The magnitude of mean velocity averaged over the first 2 s is [take, acceleration due to gravity, g = 10 m/s²]

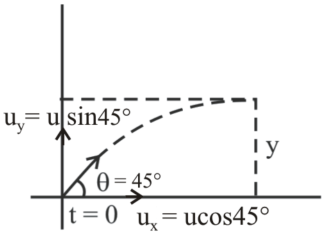
@apna_pdf

(a) 7.0 m/s (b) 8.2 m/s
(c) 7.8 m/s (d) 9 m/s

TS-EAMCET-07.05.2018, Shift-1

Ans. (b) : Given, initial velocity (u) = $2\sqrt{2}$ m/s

$\theta = 45°, t = 2$ sec



Horizontal component of velocity (u_x) = u cosθ
Vertical component of velocity (u_y) = u sinθ
Horizontal displacement (x) = $u_x \times t$

$$x = u\cos\theta \times t$$
$$x = 2\sqrt{2} \times \cos 45° \times 2$$
$$x = 2\sqrt{2} \times \frac{1}{\sqrt{2}} \times 2$$
$$x = 4 \text{ m}$$

Vertical displacement,

$$y = u_y t - \frac{1}{2}gt^2$$
$$y = u\sin 45° \times t - \frac{1}{2}gt^2$$
$$y = [2\sqrt{2}\sin 45° \times 2] - \frac{1}{2} \times 10 \times 2 \times 2$$
$$y = \left[2\sqrt{2} \times \frac{1}{\sqrt{2}} \times 2\right] - \frac{1}{2} \times 10 \times 2 \times 2$$
$$y = 4 - 20 = -16 \text{ m}$$

Total displacement,

$$d = \sqrt{x^2 + y^2}$$
$$d = \sqrt{4^2 + (-16)^2}$$
$$d = \sqrt{16 + 256} = \sqrt{272} = 16.49 \text{ m}$$

$$\because \text{ Average velocity} = \frac{\text{Total displacement}}{\text{time}}$$
$$= \frac{16.49}{2}$$
$$= 8.24 \text{ms}^{-1} \approx 8.2 \text{ ms}^{-1}$$

364. A particle aimed at a target, projected with an angle 15° with the horizontal is short of the target by 10 m. If projected with an angle of 45° is away from the target by 10 m, then the angle of projection to hit the target is

(a) $\frac{1}{2}\sin^{-1}\left(\frac{1}{4}\right)$ (b) $\frac{1}{2}\sin^{-1}\left(\frac{3}{4}\right)$
(c) $\frac{1}{2}\sin^{-1}\left(\frac{10}{4}\right)$ (d) $\frac{1}{2}\sin^{-1}\left(\frac{20}{4}\right)$

TS-EAMCET.11.09.2020, Shift-2

Ans. (b) :

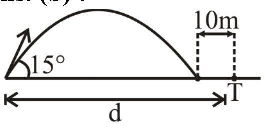


Figure-1

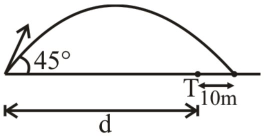


Figure-2

Let, d is the distance of target,

Horizontal range of projectile $(R) = \frac{u^2 \sin 2\theta}{g}$

When $\theta = 15°$, $R_1 = \frac{u^2 \sin(2 \times 15°)}{g} = \frac{u^2}{2g}$

When $\theta = 45°$, $R_2 = \frac{u^2 \sin(2 \times 45°)}{g} = \frac{u^2}{g}$

According to question,
From figure-1,

$$R_1 = \frac{u^2}{2g} = d - 10 \qquad \text{...(i)}$$

From figure-2,

$$R_2 = \frac{u^2}{g} = d + 10 \qquad \text{...(ii)}$$

Dividing equation (i) by equation (ii), wet get–

$$\frac{1}{2} = \frac{d-10}{d+10}$$
$$d = 30 \text{ m}$$

From equation (ii), $\frac{u^2}{g} = 30 + 10 = 40$ ...(iii)

So, the angle of projection to hit the target at 30 m,

$$30 = 40\sin 2\theta$$
$$\theta = \frac{1}{2}\sin^{-1}\left(\frac{3}{4}\right)$$

365. A ball is projected with a velocity 5 m/s, so that its horizontal range is twice the greatest height attained. The value of range is

(a) 10 m (b) 2 m
(c) 4 m (d) 5 m

TS-EAMCET-14.09.2020, Shift-1

Ans. (b) : Given that, initial velocity, u = 5 m/s and horizontal range (R) = 2 × greatest height attained (H)
We know,

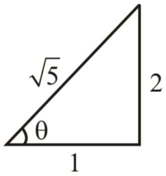
$$R = \frac{u^2 \sin 2\theta}{g} \text{ and } H_{max} = \frac{u^2 \sin^2\theta}{2g}$$

According to question, R = 2H

$$\frac{u^2 \sin 2\theta}{g} = 2\frac{u^2 \sin^2\theta}{2g}$$
$$\sin 2\theta = \sin^2\theta$$
$$2\sin\theta\cos\theta = \sin^2\theta$$
$$2\cos\theta = \sin\theta$$
$$2 = \frac{\sin\theta}{\cos\theta}$$

@apna_pdf

$$\tan\theta = \frac{2}{1}$$



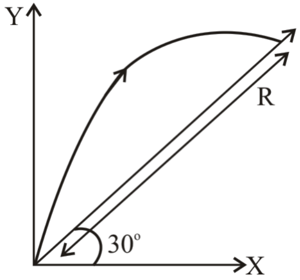
$$\sin\theta = \frac{2}{\sqrt{5}}, \quad \cos\theta = \frac{1}{\sqrt{5}}$$

$$\therefore \quad R = \frac{u^2 \sin 2\theta}{g}$$

$$R = \frac{(5)^2 \times 2\sin\theta\cos\theta}{10} = \frac{25\times 2\times\frac{2}{\sqrt{5}}\times\frac{1}{\sqrt{5}}}{10}$$

$$R = 2\text{ m}$$

366. Initial velocity with which a body is projected is 10 m/s from the base of an inclined plane as shown in the given figure. If the angle of projection is 60° with the horizontal, then the range R is [take, g = 10 m/s^2]



(a) $\frac{15\sqrt{3}}{2}$m (b) $\frac{40}{3}$m

(c) $5\sqrt{3}$m (d) $\frac{20}{3}$m

TS-EAMCET-10.09.2020, Shift-2

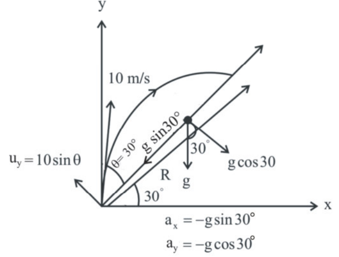
Ans. (d) : Given, initial velocity of projectile (u) = 10 m/s

Angle of projection with inclined plane,

$(\theta) = 60^o - 30^o = 30^\circ$

Horizontal component of velocity $(u_x) = u\cos 30^o$

Vertical component of velocity $(u_y) = u\sin 30^o$



Effective acceleration along inclined plane and perpendicular to inclined plane are a_x and a_y respectively.

$$\text{Time of flight (T)} = \frac{2u\sin\theta}{a_y}$$

$$T = \frac{2u\sin\theta}{g\cos\theta}$$

$$T = \frac{2\times 10\times\sin 30^o}{g\times\cos 30^o}$$

$$T = \frac{2\times 10\times\frac{1}{2}}{10\times\frac{\sqrt{3}}{2}} = \frac{2}{\sqrt{3}}\text{sec}$$

Range over an inclined plane :-

$$R = u_x t - \frac{1}{2}a_x t^2$$

$$R = 10\cos 30^o \times \frac{2}{\sqrt{3}} - \frac{1}{2}g\sin 30^o \times \frac{4}{3}$$

$$R = 10\times\frac{\sqrt{3}}{2}\times\frac{2}{\sqrt{3}} - \frac{1}{2}\times 10\times\frac{1}{2}\times\frac{4}{3}$$

$$R = 10 - \frac{10}{3} = \frac{30-10}{3} = \frac{20}{3}\text{m}$$

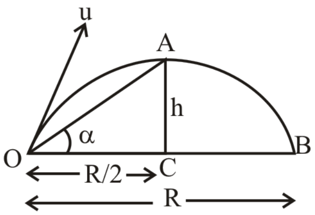
367. A projectile is fired at an angle of 45° with the horizontal. Elevation angle of the projectile at its highest point as seen from the point of projection is

(a) 60° (b) $\tan^{-1}\left(\frac{1}{2}\right)$

(c) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (d) 45°

TS-EAMCET-10.09.2020, Shift-2

Ans. (b) :



$$\text{Max. height (H)} = \frac{u^2\sin^2 45°}{2g} = \frac{u^2}{4g} = AC$$

$$\text{Horizontal range (R)} = \frac{u^2\sin(2\times 45°)}{g} = \frac{u^2}{g}$$

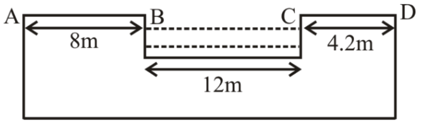
$$\therefore OC = R/2 = \frac{u^2}{2g}$$

$$\tan\alpha = \frac{AC}{OC} = \frac{u^2/4g}{u^2/2g} = \frac{1}{2}$$

$$\therefore \alpha = \tan^{-1}(1/2)$$

368. A projectile is launched from point A of the given landscape with a water body as shown in the diagram. The launching angle is 15°. From the following, identify the right initial velocity of the projectile with which it will fall somewhere in between the points C and D. [Assume, g = 10 m/s^2]

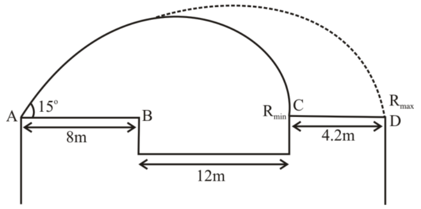
@apna_pdf



(a) 21.5 m/s (b) 22.5 m/s
(c) 19.5 m/s (d) 24.0 m/s

TS-EAMCET-10.09.2020, Shift-1

Ans. (a) :



According to given condition, range must be greater than 20 m and less than 24.2 m.

$$20 \le R \le 24.2$$

$$20 \le \frac{u^2 \sin 2\theta}{g} \le 24.2$$

$$20 \le \frac{u^2 \times \sin(2\times 15^\circ)}{10} \le 24.2$$

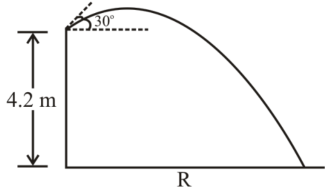
$$400 \le u^2 \le 484$$

$$20 \text{ m/s} \le u \le 22 \text{ m/s}$$

$$\therefore \quad u = \frac{20+22}{2}$$

$$u = 21.5 \text{ m/s}$$

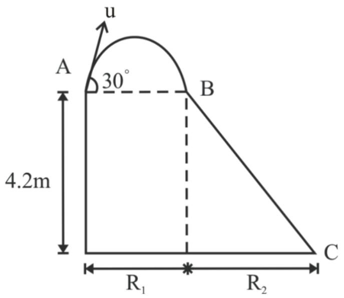
369. An archer shoots an arrow from a height 4.2 m above the ground with a speed 40 m/s and at an angle 30° as shown in the figure. Determine the horizontal distance R covered by the arrow, when it hits the ground, (take $g = 10 \text{ m/s}^2$)



(a) $\frac{185}{\sqrt{3}}$m (b) $84\sqrt{3}$m
(c) $68\sqrt{3}$m (d) $\frac{95}{\sqrt{3}}$m

TS-EAMCET-06.05.2019, Shift-1

Ans. (b) : Given, speed of arrow (u) = 40m/s, θ = 30°
h = 4.2 m



Horizontal range R_1 covered by the arrow is given by

$$R_1 = \frac{u^2 \sin 2\theta}{g} = \frac{(40)^2 \times \sin(2\times 30^\circ)}{10}$$

$$R_1 = \frac{1600 \times \sin 60^\circ}{10} = 160 \times \frac{\sqrt{3}}{2} = 80\sqrt{3} \text{ m}$$

If t be the time taken by the arrow reaching from B to C

From the second equation of motion,

$$\Rightarrow h = ut + \frac{1}{2}gt^2$$

$$4.2 = u \sin 30^\circ t + \frac{1}{2}\times 10 \times t^2 \qquad (u_y = u\sin 30^\circ)$$

$$4.2 = 20\,t + 5t^2$$

$$50\,t^2 + 200t - 42 = 0$$

$$2\,(25t^2 + 100t - 21) = 0$$

$$25t^2 + 100t - 21 = 0$$

Solving the quadratic equation, $t = \frac{1}{5}$sec

Distance travelled in horizontal direction is given by

$R_2 = u \cos 30^\circ \times t$

$$= 40 \times \frac{\sqrt{3}}{2} \times \frac{1}{5} \Rightarrow R_2 = 4\sqrt{3} \text{ m}$$

Hence, the horizontal distance covered by the arrow

$$R = R_1 + R_2$$

$$= 80\sqrt{3} + 4\sqrt{3}$$

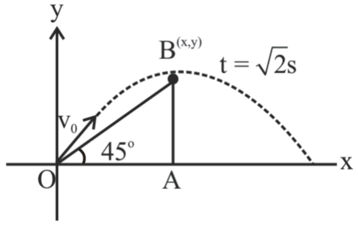
$$R = 84\sqrt{3} \text{ m}$$

370. A small object is thrown at an angle 45° to the horizontal with an initial velocity v_0. The velocity is averaged for first $\sqrt{2}$s and the magnitude of average velocity comes out to be same as that of initial velocity, i.e. $|v_0|$. The magnitude $|v_0|$ will be (take, $g = 10 \text{ m/s}^2$)

(a) 3 m/s (b) $3\sqrt{2}$ m/s
(c) 4 m/s (d) 5 m/s

TS-EAMCET-05.05.2018, Shift-1

Ans. (d) :



Let object is at B (x, y) after $t = \sqrt{2}$s

Then, $x = u_x \times t = v_0 \cos 45^0 \times \sqrt{2} = v_0$

and $y = u_y t - \frac{1}{2}a_y t^2$

$$= v_0(\sin 45^\circ)\sqrt{2} - \frac{1}{2}(10)\times(\sqrt{2})^2 \qquad [\because a_y = g]$$

$$= (v_0 - 10)\text{m}$$

Displacement OB of particle is

$$OB = \sqrt{OA^2 + AB^2} = \sqrt{v_0^2 + (v_0 - 10)^2}$$

@apna_pdf

So, $v_{avg} = \frac{OB}{t} = v_0$ or $OB = v_0 t$

$\sqrt{v_0^2 + (v_0 - 10)^2} = v_0\sqrt{2} \Rightarrow v_0^2 + (v_0 - 10)^2 = 2v_0^2$

$(v_0 - 10)^2 = v_0^2$

$v_0^2 + 100 - 20v_0 = v_0^2$

$20v_0 = 100 \Rightarrow v_0 = 5$ m/s

371. A cricket player can throw a ball with an initial speed of 30 m/s. What is the maximum range of the player can throw the ball? Neglect air resistance. [Take, g = 10 m/s^2]

(a) 100 m (b) 90 m

(c) 80 m (d) $90\sqrt{2}$ m

TS-EAMCET-05.05.2018, Shift-2

Ans. (b) : Given, u = 30 m/s, g = 10 m/s^2

$\because \quad R = \frac{u^2 \sin 2\theta}{g}$

For R to be maximum then sin 2θ = 1 or θ = 45°

$R = \frac{u^2 \sin 2\theta}{g}$

$R = \frac{(30)^2 \times (1)^2}{10} = \frac{900 \times 1}{10} = 90$ m

372. A boy standing on a moving truck throws a projectile such that he is able to catch it back after the truck has moved 100 m. If the truck is moving horizontally along a straight line with a constant speed 30 m/s, at what speed (relative to the truck) must the projectile is thrown. (Assume g = 10 m/s^2)

(a) $\frac{55}{3}$ m/s (b) $\frac{43}{2}$ m/s

(c) $\frac{50}{3}$ m/s (d) $\frac{23}{2}$ m/s

TS-EAMCET-04.05.2019, Shift-2

Ans. (c) : Given, velocity of truck = 30 m/s

g = 10 m/s^2

Time taken by truck to move 100m

$t = \frac{100}{30} = \frac{10}{3}$ sec.

Distance taken by projectile t_1 to reach maximum height is given by

$$s = ut + \frac{1}{2}at^2$$

$$0 = ut + \frac{1}{2}(-g)t^2$$

$$2ut = gt^2$$

$$u = \frac{gt}{2}$$

$$u = \frac{10 \times \frac{10}{3}}{2} = \frac{100}{6} = \frac{50}{3} \text{ m/s}$$

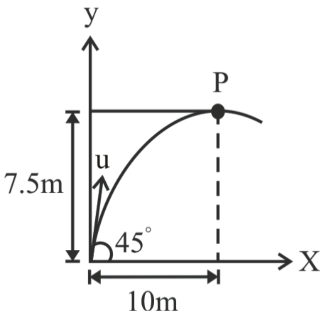
373. A particle is projected from the ground with some initial velocity making an angle of 45^o with the horizontal. If it reaches a height of 7.5 m above the ground, while it travels a horizontal distance of 10 m from the point of projection, then the initial speed of particle is (assume, g = 10 m/s^2)

(a) 10 m/s (b) 20 m/s

(c) 15 m/s (d) 25 m/s

TS-EAMCET-09.09.2020, Shift-2

Ans. (b) :



Angle of projection = 45°

Vertical height (h_y) = 7.5m

Horizontal distance (h_x) = 10m

$s_x = u.\cos\theta.t = u\cos 45^o.t$

$$10 = u \times \frac{1}{\sqrt{2}} \times t$$

$$t = \frac{10\sqrt{2}}{u} \quad \text{.... (1)}$$

$$s_y = u \sin\theta t - \frac{1}{2}gt^2$$

$$7.5 = \frac{u}{\sqrt{2}} \times \frac{10\sqrt{2}}{u} - \frac{1}{2} \times \frac{10 \times 10 \times 10 \times 2}{u^2}$$

$$7.5 = 10 - \frac{1000}{u^2}$$

$$10 - 7.5 = \frac{1000}{u^2}$$

$$2.5 = \frac{1000}{u^2}$$

$$u^2 = \frac{1000}{2.5}$$

$$u^2 = 400$$

u = 20 m/s

374. Two bodies are projected at angles θ and (90^o– θ) to the horizontal with the same speed. The ratio of their times of flight is

(a) sin θ :1 (b) cos θ :1

(c) sin θ : cos θ (d) cosθ : sin θ

JCECE-2017

@apna_pdf

Ans. (c) : For the first body angle of projection is θ

So, time of flight $(T_1) = \dfrac{2u\sin\theta}{g}$ ....(i)

For the second body angle of projection is (90 – θ)

Time of flight $(T_2) = 2u\sin\dfrac{(90^\circ-\theta)}{g}$

$T_2 = 2u\dfrac{\cos\theta}{g}$ .... (ii)

Dividing equation (i) and (ii), we have

$$\frac{T_1}{T_2} = \frac{\dfrac{2u\sin\theta}{g}}{\dfrac{2u\cos\theta}{g}}$$

$$\frac{T_1}{T_2} = \frac{\sin\theta}{\cos\theta}$$

The ratio of time of flight

$$\boxed{T_1 : T_2 = \sin\theta : \cos\theta}$$

375. A shell bursts on contact with the ground and pieces from it fly in all directions with velocities upto 60 m/s. Find the time in which a man 180 m away is in danger.

(a) $2\sqrt{3}$ s (b) $6\sqrt{2}$ s

(c) $4\sqrt{3}$ s (d) None of these

JCECE-2016

Ans. (b) : Given, u = 60 m/s, R = 180 m

We know that,

Horizontal range $(R) = \dfrac{u^2}{g}\sin 2\theta$

$$180 = \frac{(60)^2}{10}\sin 2\theta$$

$$\sin 2\theta = \frac{1}{2} = \sin 30^\circ$$

$$\theta = 15^\circ$$

As there are always two directions of projections θ and (90° – θ) for the given range, hence two directions of projection, i.e. 15° and 90° – 15°, i.e. 15° and 75°

Let T_1 and T_2 be the times of flight in the two cases,

Where, $T_1 = \dfrac{2u\sin 15^\circ}{g}$ and $T_2 = \dfrac{2u\sin 75^\circ}{g}$

The man is in danger for a time

$$T_2 - T_1 = \frac{2u}{g}(\sin 75^\circ - \sin 15^\circ)$$

$$= \frac{2u}{g}(2\cos 45^\circ \sin 30^\circ)$$

$$\left[\text{using identity}, \sin C - \sin D = 2\cos\frac{C+D}{2}\sin\frac{C-D}{2}\right]$$

$$= \frac{2\times 60}{10}\times 2\times\frac{1}{\sqrt{2}}\times\frac{1}{2} = 6\sqrt{2}\text{ s}$$

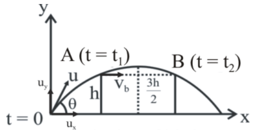
376. A stone is projected from the point on the ground in such a direction so as to hit a bird on the top of a telegraph post of height and then attain the maximum height 3h/2 above the ground. If at the instant of projection, the bird were to fly away horizontally with uniform speed. Find the ratio between horizontal velocities of the bird and stone, if the stone still hits the bird while decreasing.

(a) $\sqrt{3}-1$ (b) $1/\sqrt{3}-1$

(c) $\sqrt{3}+1$ (d) $1/\sqrt{3}+1$

JCECE-2015

Ans. (a) :



v_b- velocity of bird

$$t_1 + t_2 = \frac{2u_y}{g} \quad ....(i)$$

For motion of the stone in vertical direction we can say

$$h = u_y t - \frac{1}{2}gt^2$$

$gt^2 - 2u_yt + 2h = 0$ ....(ii)

t_1 and t_2 are the roots of equation (ii)

$$t_1t_2 = \frac{2h}{g} \quad ....(iii)$$

$$H = \frac{3h}{2} = \frac{u_y^2}{2g} \qquad \left[\because H = \frac{3h}{2}\right]$$

$$u_y = \sqrt{3gh} \quad ....(iv)$$

Putting the value of u_y in equation (i), we get–

$$t_1 + t_2 = 2\sqrt{\frac{3h}{g}} \quad ....(v)$$

and $t_1t_2 = \dfrac{2h}{g}$

$(t_2 - t_1)^2 = (t_1+t_2)^2 - 4t_1t_2$

$$= \frac{12h}{g} - \frac{8h}{g} = \frac{4h}{g}$$

$$t_2 - t_1 = 2\sqrt{\frac{h}{g}} \quad ....(vi)$$

From equation (v) and (vi), we get–

$$t_2 = \sqrt{\frac{h}{g}}\left(\sqrt{3}+1\right)$$

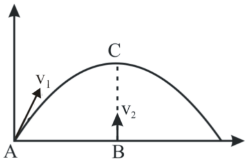
$AB = v_b\, t_2 = u_x\,(t_2 - t_1)$

∴ Ratio of horizontal velocities of bird and stone

$$\frac{v_b}{u_x} = \frac{t_2 - t_1}{t_2} = \frac{2}{\sqrt{3}+1} = \sqrt{3}-1$$

@apna_pdf

377. A body is projected with velocity v_1 from the point A, another body at the same time is projected vertically upwards from B with velocity v_2 as shown in adjoining figure. If the point B lies vertically below the highest point C, then for both bodies to collide the ratio $\frac{v_2}{v_1}$ should be



(a) 0.5 (b) 1

(c) $\frac{\sqrt{3}}{2}$ (d) $\frac{2}{\sqrt{3}}$

JCECE-2013

Ans. (a) : The two bodies will collide at the highest point if both cover the same vertical height in the same time

$$H = \frac{u^2\sin^2\theta}{2g}$$

So, $$\frac{v_1^2\sin^2 30^o}{2g} = \frac{v_2^2}{2g}$$

or $$\frac{v_2^2}{v_1^2} = \sin^2 30^\circ$$

$$\frac{v_2}{v_1} = \sin 30^\circ = \frac{1}{2} = 0.5$$

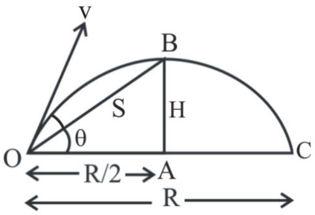
378. A particle is projected from the ground with an initial speed of v at an angle θ with horizontally. The average velocity of the particle between its point of projection and highest point of trajectory is

(a) $\frac{v}{2}\sqrt{1+2\cos^2\theta}$ (b) $\frac{v}{2}\sqrt{1+2\cos^2\theta}$

(c) $\frac{v}{2}\sqrt{1+3\cos^2\theta}$ (d) v cos θ

JCECE-2011
AP EAMCET - 2013

Ans. (c) :



$$\text{Average velocity (v)} = \frac{\text{Total displacement}}{\text{Total time}}$$

From point O to B, the displacement S is,

$$S = \sqrt{H^2 + \left(\frac{R}{2}\right)^2} \quad .....(i)$$

$$\text{Total time} = \frac{T}{2}$$

Here, $$H = \frac{v^2\sin^2\theta}{2g}, R = \frac{v^2\sin 2\theta}{g}$$

$$T = \frac{2u\sin\theta}{g}$$

Putting these value in equation (i), we get–

$$\text{Average velocity (v)} = \frac{\sqrt{\left(\frac{v^2\sin^2\theta}{2g}\right)^2 + \left(\frac{v^2\sin 2\theta}{2g}\right)^2}}{\frac{2v\sin\theta}{2g}}$$

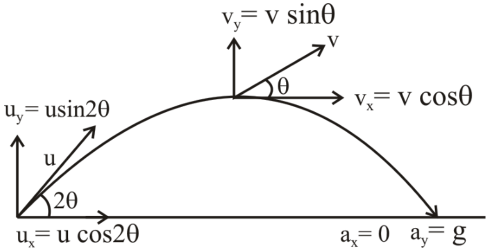
$$v_{avg} = \frac{v}{2}\sqrt{1+3\cos^2\theta}$$

379. A projectile is fired making an angle 2θ with horizontal with velocity 4m/s. At any instant it makes an angle θ, then its velocity is :

(a) 4 cos θ
(b) 4 (2 cos θ – sec θ)
(c) 2 (sec θ + 4 cos θ)
(d) 4 (sec θ + cos θ)

JCECE-2006

Ans. (b) : Given that, u = 4 m/s



Resolving the component along the x-axis and y-axis. Now equating the velocity along the horizontal component

$$u_x = v_x$$

$$u \cos 2\theta = v \cos\theta$$

$$\frac{4\cos 2\theta}{\cos\theta} = v$$

$$v = \frac{4(2\cos^2\theta - 1)}{\cos\theta} \quad [\because \cos 2\theta = \cos^2\theta - 1]$$

$$v = 4\left(2\cos\theta - \frac{1}{\cos\theta}\right) \quad \left[\because \frac{1}{\cos\theta} = \sec\theta\right]$$

So, $v = 4[2\cos\theta - \sec\theta]$

380. A rifle shoots a bullet with a muzzle velocity of 500 ms^{-1} at a small target 50 m away. To hit the target the rifle must be aimed:
(Take g = 10 ms^{-2})

(a) exactly at the target
(b) 10 cm below the target
(c) 10 cm above the target
(d) 5 cm above the target

JCECE-2005

@apna_pdf

Ans. (d) : Given that, s = 50 m, v = 500 m/s

We know that,

Distance (s) = speed (v) × time (t)

$$s = v \times t$$

$$t = \frac{s}{v}$$

$$t = \frac{50}{500} = 0.1\text{sec}$$

From equation of motion, vertical displacement will be given by

$$h = ut + \frac{1}{2}gt^2$$

$u = 0$, $t = 0.1$ sec

$$h = 0 + \frac{1}{2} \times 10 \times 0.1 \times 0.1$$

$$h = .05\text{ m} = 0.05 \times 100$$

$$h = 5\text{ cm}$$

381. The body is projected at such angle that the horizontal range is three times the greatest height. The angle of projection is :

(a) 43°8'
(b) 25°8'
(c) 33°7'
(d) 53°1'

BCECE-2007
JCECE-2003
AIIMS-1998

Ans. (d) : Given, R = 3H

A body is projected at a velocity u with an angle θ with the horizontal then.

Range of the body–

$$R = \frac{u^2 \sin 2\theta}{g}$$

Maximum height attained the body is given by

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

Putting the value of R and H in equation (i)

$$\frac{u^2 \sin 2\theta}{g} = 3 \times \frac{u^2 \sin^2 \theta}{2g}$$

$(\sin 2\theta = 2\sin\theta\cos\theta)$

$$\frac{u^2 2\sin\theta\cos\theta}{g} = 3 \times \frac{u^2 \sin^2 \theta}{2g}$$

$$\frac{\sin\theta}{\cos\theta} = \tan\theta = \frac{4}{3} = 1.33$$

$$\theta = 53°1'$$

382. Two projectiles, one fired from earth with 5m s^{-1} and the other fired from a planet with 3m s^{-1} trace identical trajectories. If acceleration due to gravity on earth is 9.8m s^{-2}, then the acceleration due to gravity on the planet is

(a) 1.5m s^{-1}
(b) 3.5m s^{-1}
(c) 7.5m s^{-2}
(d) 9.5m s^{-2}

COMEDK 2017
[AIPMT 2011]

Ans. (b) : Given that,

$u_1 = 5$ m/s, $u_2 = 3$ m/s, $g = 9.8$ m/s^2

They trace identical trajectory, that means their range is same.

Range of projectile is given by

$$R = \frac{u^2 \sin 2\theta}{g}$$

For Earth

$$R_1 = \frac{u_1^2 \sin 2\theta}{g}$$

For planet

$$R_2 = \frac{u_2^2 \sin 2\theta}{g'}$$

$$R_1 = R_2$$

$$\frac{u_1^2 \sin 2\theta}{g} = \frac{u_2^2 \sin 2\theta}{g'}$$

$$g' = \frac{u_2^2}{u_1^2} \times g$$

$$g' = \left(\frac{3}{5}\right)^2 \times 9.8$$

$$= \frac{9}{25} \times 9.8$$

$$= 3.528\text{ms}^{-1}$$

383. An arrow is shot into air. Its range is 200 m and its time of flight is 5 second. If $g = 10\text{m s}^{-2}$, then the horizontal component of the velocity of arrow is

(a) 12.5m s^{-1}
(b) 25ms^{-1}
(c) 31.25m s^{-1}
(d) 40m s^{-1}

COMEDK 2016

Ans. (d) : Given, R = 200, T = 5

We know that,

$$\text{Time of flight of projectile} \quad T = \frac{2u\sin\theta}{g}$$

$$\text{And,} \quad R = \frac{u^2 \sin 2\theta}{g} = \frac{2u\sin\theta}{g} u\cos\theta$$

$$R = T \times u\cos\theta$$

$$200 = 5 \times u\cos\theta$$

$$u\cos\theta = 40\text{ m/s}$$

384. If $(\text{range})^2$ is $4\sqrt{3}$ time $(\text{maximum height})^2$, then angle of projection is

(a) 45°
(b) 60°
(c) 75°
(d) 30°

COMEDK 2018

Ans. (d) : We know that,

Height of projectile

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

$$\text{Range (R)} = \frac{u^2 \sin 2\theta}{g}$$

@apna_pdf

Given,

$(\text{Range})^2 = 4\sqrt{3}\ (\text{maximum height})^2$

$$\therefore\ \left(\frac{u^2\sin 2\theta}{g}\right)^2 = 4\sqrt{3}\left(\frac{u^2\sin^2\theta}{2g}\right)^2$$

$$\frac{u^2\sin 2\theta}{g} = 4\sqrt{3}\left(\frac{u^2\sin^2\theta}{2g}\right)$$

$$\frac{2\sin\theta\cos\theta}{4\sqrt{3}} = \frac{\sin^2\theta}{2}$$

$$\tan\theta = \frac{4}{4\sqrt{3}}$$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

$$\therefore\quad \theta = 30°$$

385. Assertion: The trajectory of projectile is quadratic in y and linear in x.

Reason: y component of trajectory is independent of x- component.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(E)

Ans. (d) : We know that the trajectory of a projectile motion in the y-direction is given by

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

From above equation it is clear that the nature of the trajectory of a projectile is linear in the y-direction and quadratic in the x-direction.

And y-component is not independent of the x-component of the projectile motion.

It is clear that both the assertions as well as reason are incorrect.

386. Assertion: A tennis ball bounces higher on hills than in plains.

Reason: Acceleration due to gravity on the hill is greater than that on the surface of earth.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-2009

Ans. (c) : Consider the tennis ball bounces with a velocity u. It will go up, till its velocity becomes zero. If h is the height up to which it rises on the hill, then

$$(0)^2 - u^2 = 2(-g)h$$

Where, g is acceleration due to gravity on the hill.

$$h = \frac{u^2}{2g}$$

Since, the acceleration due to gravity on the hill (g) is less than that on earth (effect of height). It is clear that the ball will get maximum height on the hills than in plains.

387. Two projectiles are fired from the same point with the same speed at angle of projection 60° and 30° respectively. Which one of the following is true?

(a) Their maximum height will be same

(b) Their range will be same

(c) Their landing velocity will be same

(d) Their time of flight will be same

AIIMS-2014

Ans. (b) : Given that,

$u_1 = u_2 = u \qquad \theta_1 = 60°,\ \theta_2 = 30°$

In Ist case:

We know that range

$$R_1 = \frac{u^2\sin 2(60°)}{g} = \frac{u^2\sin 120°}{g} = \frac{u^2\sin(90°+30°)}{g}$$

$$= \frac{u^2(\cos 30°)}{g} = \frac{\sqrt{3}u^2}{2g}$$

In IInd case:

When $\theta_2 = 30°$, then

$$R_2 = \frac{u^2\sin 60°}{g} = \frac{u^2\sqrt{3}}{2g}$$

Hence, from the above, it is clear–

$$R_1 = R_2$$

It means, their range will be same.

388. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 m/s at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground?

$$\left[g = 10\text{m/s}^2, \sin 30° = \frac{1}{2}, \cos 30° = \frac{\sqrt{3}}{2}\right]$$

(a) $5\sqrt{5}$ (b) 6

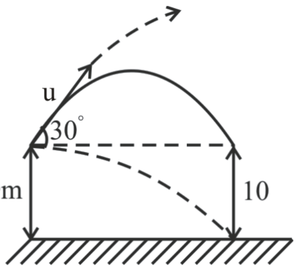
(c) 3 (d) $5\sqrt{3}$

AIIMS - 2017

AIEEE - 2003

Ans. (d) : Given that,

h = 10 m



From building throws a ball with speed (u) = 10 m/s

@apna_pdf

We know,

The range of projectile $(R) = \dfrac{u^2 \sin 2\theta}{g}$

$$R = \frac{10^2 \sin 2(30^o)}{g}$$

$$R = \frac{100 \sin(60^o)}{10}$$

$$R = 10 \times \frac{\sqrt{3}}{2} \Rightarrow R = 5\sqrt{3}$$

389. A body is projected from the ground with a velocity 50 m/s at an angle of 30°. It crosses a wall after 3 sec. How far beyond the wall the body will strike the ground? [take g = 10 m/s^2]

(a) 86.6 m (b) 96.2 m

(c) 100.1 m (d) 111.1 m

AIIMS-26.05.2018(M)

BCECE-2012

Ans. (a) : Given that-

Velocity (u) = 50m/s

Angle $(\theta) = 30°$

We know that time of fight-

$$T = \frac{2u\sin\theta}{g}$$

$$T = \frac{2 \times 50 \times \sin 30°}{10} \qquad \left(\sin 30^o = \frac{1}{2}\right)$$

$$T = \frac{2 \times 50 \times \frac{1}{2}}{10}$$

$$T = 5\text{sec}$$

Time in air after crossing the wall

$$t = 5 - 3\text{sec}$$

$$t = 2\text{sec}.$$

So, Distance travelled beyond the wall

$$d = u\cos\theta \times t$$

$$d = 50 \times \cos 30° \times 2 \qquad \left(\cos 30^o = \frac{\sqrt{3}}{2}\right)$$

$$d = 50 \times \frac{\sqrt{3}}{2} \times 2$$

$$d = 50\sqrt{3} \Rightarrow d = 86.6\text{m}$$

390. A projectile can have the same range for two angles of projection. If h_1 and h_2 are maximum heights when the range in the two cases is R, then the relation between R, h_1 and h_2 is

(a) $R = 4\sqrt{h_1h_2}$ (b) $R = 2\sqrt{h_1h_2}$

(c) $R = \sqrt{h_1h_2}$ (d) None of these

AIIMS-2013

Ans. (a) : Let the angle of projection θ and range R, hence maximum height (h) attend correspond to this angle-

$$h_1 = \frac{u^2 \sin^2\theta}{2g}$$

For equal range (R), the projection of the angle should be θ and $(90-\theta)$ from horizontal, so maximum height (h_2) for $(90-\theta)$ angle of projection is -

$$h_2 = \frac{u^2 \sin^2(90-\theta)}{2g}$$

and $$R = \frac{u^2 \sin 2\theta}{g}$$

$\therefore$ $$h_1h_2 = \frac{u^2 \sin^2\theta}{2g} \times \frac{u^2 \sin^2(90-\theta)}{2g}$$

$$h_1h_2 = \frac{u^4 \sin^2\theta.\sin^2(90-\theta)}{4g^2}$$

$$h_1h_2 = \frac{u^4 \sin^2\theta\cos^2\theta}{4g^2}$$

$$h_1h_2 = \frac{u^4(\sin\theta\cos\theta)^2}{4g^2}$$

$\therefore$ Multiply and divide by 4

$$h_1h_2 = \frac{u^2(2\sin\theta\cos\theta)^2}{4 \times 4g^2}$$

$$h_1h_2 = \frac{u^4(\sin 2\theta)^2}{16g^2} \qquad (\because \sin 2\theta = 2\sin\theta\cos\theta)$$

$$h_1h_2 = \frac{(u^2 \sin 2\theta)^2}{16g^2}$$

$$h_1h_2 = \frac{R^2}{16}$$

$$R^2 = 16h_1h_2$$

$$R = \sqrt{16h_1h_2} = 4\sqrt{h_1h_2}$$

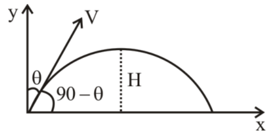
391. A projectile thrown with velocity v making angle θ with vertical gains maximum height H in the time for which the projectile remains in air, the time period is

(a) $\sqrt{H\cos\theta/g}$ (b) $\sqrt{2H\cos\theta/g}$

(c) $\sqrt{4H/g}$ (d) $\sqrt{8H/g}$

AIIMS-2013

Ans. (d) :



Maximum height $(H) = \dfrac{v^2 \sin^2(90-\theta)}{2g}$

$$= \frac{v^2 \cos^2\theta}{2g} \qquad .....(i)$$

@apna_pdf

Time of fight (T) $= \dfrac{2v\sin(90°-\theta)}{g}$

$$T = \frac{2v\cos\theta}{g}$$

$$\frac{v\cos\theta}{g} = \frac{T}{2} \qquad .....(ii)$$

From equation (i)–

$$H = \frac{1}{2}\left(\frac{v\cos\theta}{g}\right)\left(\frac{v\cos\theta}{g}\right)\times g \qquad .....(iii)$$

From equation (ii) and (iii)–

$$H = \frac{1}{2}\left(\frac{T}{2}\right)\times\left(\frac{T}{2}\right)\times g, \qquad H = \frac{T^2 g}{8}$$

$$8H = T^2 g$$

$$T^2 = \frac{8H}{g}, \qquad T = \sqrt{\frac{8H}{g}}$$

392. A bomb is released from a horizontal flying aeroplane. The trajectory of bomb is

(a) a parabola (b) a straight line

(c) a circle (d) a hyperbola

AIIMS-2013

Ans. (a) : When a bomb is released from an aeroplane it follows a parabolic trajectory with a horizontal speed equal to that of the aeroplane.

However, due to frictional force, it eventually loses this velocity and gravitational force acting on it produces a vertical acceleration on it and it starts to fall towards the ground.

Hence, the trajectory of the bomb forms a parabola with respect to ground.

3993. For a given angle of the projectile if the initial velocity is doubled the range of the projectile becomes

(a) Half (b) One-fourth

(c) Two times (d) Four times

AIIMS-2011

Ans. (d) : Let R is the range of initial velocity.

We know that-

$$R = \frac{u^2\sin 2\theta}{g}$$

When initial velocity is doubled (i.e. u' = 2u)

Then range,

$$R' = \frac{(u')^2\sin 2\theta'}{g}$$

$$R' = \frac{(2u)^2\sin 2\theta}{g}$$

$$R' = \frac{4u^2\sin 2\theta}{g}$$

So, $R' = 4R$

If initial velocity of a projectile be doubled R will be becomes 4 times.

394. An aircraft executes a horizontal loop with a speed of 150 m/s with its wings banked at an angle of 12°. The radius of the loop is (g = 10 m/s^2)

(a) 10.6 km (b) 9.6 km

(c) 7.4 km (d) 5.8 km

AIIMS-2010

Ans. (a) : Given that,

v = 150 m/s, angle θ = 12°, g = 10 m/s^2

Using the relation for the radius (r) of loop.

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan 12° = \frac{v^2}{rg}$$

$$\tan 12° = \frac{(150)^2}{r\times 10}$$

$$0.2126 = \frac{22,500}{r\times 10} = \frac{2250}{r}$$

$$r = \frac{2250}{0.2126} \Rightarrow r = 10583.25 \text{ m}$$

$$r = 10.583\text{km} \approx 10.6 \text{ km}$$

395. If R and H represent the horizontal range and the maximum height achieved by a projectile then which of the relation exists?

(a) $\dfrac{H}{R} = 4\cot\theta$ (b) $\dfrac{R}{H} = 4\cot\theta$

(c) $\dfrac{H}{R} = 4\tan\theta$ (d) $\dfrac{R}{H} = 4\tan\theta$

AIIMS-2009

Ans. (b) : Range $(R) = \dfrac{u^2\sin 2\theta}{g}$

$$R = \frac{2u^2\sin\theta\cos\theta}{g} \qquad ....(i)$$

Height (H) $= \dfrac{u^2\sin^2\theta}{2g}$ ....(ii)

On dividing equation (ii) by (i), we get–

$$\therefore \quad \frac{H}{R} = \frac{\dfrac{u^2\sin^2\theta}{2g}}{\dfrac{2u^2\sin\theta\cos\theta}{g}}$$

$$\frac{H}{R} = \frac{u^2\sin^2\theta}{2g}\times\frac{g}{2u^2\sin\theta\cos\theta}$$

$$\frac{H}{R} = \frac{\sin\theta}{4\cos\theta}$$

$$\frac{R}{H} = \frac{4\cos\theta}{\sin\theta}$$

$$\frac{R}{H} = 4\cot\theta$$

@apna_pdf

396. The maximum range of a gun horizontal terrain is 16 km. If g = 10 m/s^2. what must be the muzzle velocity of the shell

(a) 400 m/s (b) 200 m/s
(c) 100 m/s (d) 50 m/s

AIIMS-2004
CGPET-2010
AIPMT - 1990
JIPMER - 2005

Ans. (a) : We know,

Horizontal range $(R) = \frac{u^2 \sin 2\theta}{g}$

For maximum range $(\theta) = 45°$

$$R_{max} = \frac{u^2 \sin(2\times45°)}{g}$$

$$= \frac{u^2 \sin(90°)}{g} \qquad (\sin 90° = 1)$$

$$R_{max} = \frac{u^2}{g}$$

$$16000 = \frac{u^2}{10}$$

$$u^2 = 16000\times10$$

$$u = \sqrt{160000}$$

$\therefore$ u = 400 m/sec

397. Two projectiles are projected with the same velocity. If one is projected at an angle of 30° and the other at 60° to the horizontal, the ratio of maximum heights reached, is

(a) 1:3 (b) 2:1
(c) 3:1 (d) 1:4

AIIMS-2001

Ans. (a) : Given that,

$$\theta_1 = 30°, \theta_2 = 60°$$

We know,
Maximum height -

$$H = \frac{u^2 \sin^2\theta}{2g}$$

Then, $\theta = 30°$

$$H_1 = \frac{u^2 \sin^2 30°}{2g} \qquad ....(i)$$

And, $\theta = 60°$

$$H_2 = \frac{u^2 \sin^2 60°}{2g} \qquad ....(ii)$$

On dividing equation (i) by (ii), we get-

$$\frac{H_1}{H_2} = \frac{\sin^2 30°}{\sin^2 60}$$

$$\frac{H_1}{H_2} = \frac{(1/2)^2}{(\sqrt{3}/2)^2}$$

$$\frac{H_1}{H_2} = \frac{1/4}{3/4}$$

$$\frac{H_1}{H_2} = \frac{1}{3}$$

Hence, $H_1 : H_2 = 1:3$

398. Ratio between maximum range and square of time of flight in projectile motion is

(a) $\frac{g}{2}$ (b) $\frac{g}{5}$
(c) $\frac{g}{10}$ (d) $\frac{g}{12}$

AIIMS-26.05.2019(E) Shift-2

Ans. (a) : We know,

$$\text{Range } (R) = \frac{u^2 \sin 2\theta}{g}$$

For maximum range (θ = 45°)

$$R_{max} = \frac{u^2 \sin 2\times45°}{g}$$

$$R_{max} = \frac{u^2 \sin 90°}{g} \qquad (\sin 90° = 1)$$

$$R_{max} = \frac{u^2}{g}$$

Time of flight $(T) = \frac{2u\sin\theta}{g}$

$$T = \frac{2u \sin 45°}{g} \qquad (\because \sin 45° = \frac{1}{\sqrt{2}})$$

$$T = \frac{2u\times1}{\sqrt{2}g}$$

$$T = \frac{\sqrt{2}u}{g} \Rightarrow T^2 = \frac{2u^2}{g^2}$$

Then, Ratio of R_{max} and time of fight-

$$\frac{R_{max}}{T^2} = \frac{u^2/g}{2u^2/g^2} = \frac{g}{2}$$

399. A cricketer can throw a ball to a maximum horizontal distance of 100 m. The speed with which he throws the ball is (to the nearest integer)

(a) 30 ms^{-1} (b) 42 ms^{-1}
(c) 32 ms^{-1} (d) 35 ms^{-1}

AIIMS-26.05.2019(M) Shift-1

Ans. (c) : We know,

$$\text{Range } (R) = \frac{u^2 \sin 2\theta}{g}$$

For maximum horizontal range $\theta = 45°$

$$R_{max} = \frac{u^2 \sin 2\times45°}{g}$$

$$R_{max} = \frac{u^2 \sin 90}{g} \qquad (\sin 90° = 1)$$

@apna_pdf

$$100 = \frac{u^2 \times 1}{10}$$
$$u^2 = 100 \times 10$$
$$u^2 = 1000$$
$$u = \sqrt{1000}$$
$$u = 10\sqrt{10}$$
$$u = 10 \times 3.16$$
$$u = 31.62$$
$$u \approx 32 \text{m/s}$$

400. Assertion: Three projectiles are moving in different paths in the air. Vertical component of relative velocity between any of the pair does not change with time as long as they are in air. (Neglecting the effect of air friction)

Reason: Relative acceleration between any of the pair of projection is zero.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (a) : Acceleration of projectile = $\vec{g}$

Relative acceleration $\vec{a}_r = \vec{g} - \vec{g}$

$$\vec{a}_r = 0$$

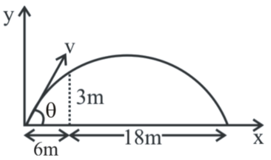
Because g is same for the bodies hence, their relative acceleration is zero this implies their relative velocity doesn't change with time.

401. A ball is thrown from the ground to clear a wall 3m high at a distance of 6m and falls 18m away from the wall, the angle of projection of ball is-

(a) $\tan^{-1}\left(\frac{3}{2}\right)$ (b) $\tan^{-1}\left(\frac{2}{3}\right)$
(c) $\tan^{-1}\left(\frac{1}{2}\right)$ (d) $\tan^{-1}\left(\frac{3}{4}\right)$

BCECE-2015

Ans. (b) :



The equation of trajectory of projectile,

$$y = x\left[1 - \frac{x}{R}\right]\tan\theta$$

Put y = 3m, x = 6m and R = 24 m

$$3 = 6\left[1 - \frac{6}{24}\right]\tan\theta$$
$$3 = 6\left[1 - \frac{1}{4}\right] \times \tan\theta$$
$$\tan\theta = \frac{2}{3}, \quad \theta = \tan^{-1}\left(\frac{2}{3}\right)$$

402. A man fires a large number of bullets in all directions with same speed u. The maximum area on the ground on which these bullets will spread is-

(a) $\frac{\pi u^2}{g}$ (b) $\frac{u^2}{g^2}$
(c) $\frac{\pi u^4}{g^2}$ (d) $\frac{u^4}{g^2}$

BCECE-2014

Ans. (c) : The range of the projectile $(R) = \frac{u^2 \sin 2\theta}{g}$

For maximum $\theta = 45°$

$$R_{max} = \frac{u^2 \sin(2 \times 45°)}{g}$$
$$R_{max} = \frac{u^2 \sin 90°}{g}$$
$$R_{max} = \frac{u^2}{g}$$

Area in which bullet will spread = πR^2

Maximum area $\left(\pi R^2_{max}\right) = \pi\left(\frac{u^2}{g}\right)^2 = \frac{\pi u^4}{g^2}$

403. A bullet fired at an angle of 30^0 with the horizontal hits the ground 3km away. By adjusting its angle of projection, can one hope to hit a target 5km away. Assume the muzzle speed to be same and the air resistance is negligible–

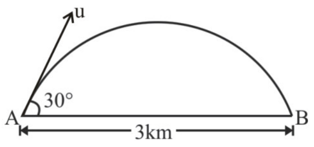
(a) possible to hit a target 5km away
(b) not possible to hit a target 5km away
(c) prediction is not possible
(d) none of the above

BCECE-2007

Ans. (b) : Given that -

Range (R) = 3km

Angle of projection of bullet = 30°



Horizontal range for the projection,

$$R = \frac{u^2 \sin 2\theta}{g}$$
$$3 = \frac{u^2 \sin(2 \times 30°)}{g}$$
$$3 = \frac{u^2 \sin 60°}{g} \quad \left(\because \sin 60° = \frac{\sqrt{3}}{2}\right)$$
$$3 = \frac{u^2 \times \frac{\sqrt{3}}{2}}{g}$$

@apna_pdf

$$\frac{u^2}{g} = \frac{3\times 2}{\sqrt{3}}$$

$$\frac{u^2}{g} = 2\sqrt{3}$$

$$\frac{u^2}{g} = 3.46\,\text{km} \qquad .....(i)$$

The maximum range (R_{max}) is achieved by the bullet when it is fired at angle 45° with the horizontal that is-

$$R_{max} = \frac{u^2}{g} \qquad .....(ii)$$

On comparing eq^n (i) and (ii), we get –

R_{max} = 3.464 km

Hence, the bullet will not hit a target 5 km away.

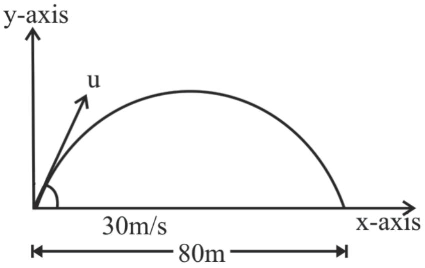
404. A car is moving horizontally along a straight line with constant speed 30m/s. A projectile is to be fired from the moving car in such a way that it will return to the car after the car has moved 80m. At what speed (relative to the car) must the projectile be fired?
(Take g = 10 m/s^2)

(a) 10m/s (b) $10\sqrt{8}$m/s

(c) $\frac{40}{3}$m/s (d) None of these

BCECE-2006

Ans. (c) : Given, velocity (u_x) = 30 m/s, range (R) = 80 m, g = 10 m/s^2



$$R = u_x.T \Rightarrow T = \frac{R}{u_x}$$

$$T = \frac{80}{30} = \frac{8}{3}\text{sec}$$

$$\text{Time of flight } (T) = \frac{2u_y}{g}$$

$$u_y = \frac{T\times g}{2} = \frac{8/3\times 10}{2}$$

$$u_y = \frac{40}{3}\text{sec}$$

405. At the height 80m, an aeroplane is moved with 150m/s. A bomb is dropped from it, so as to hit a target. At what distance from the target should the bomb be dropped ? (g = 10 m/s^2)

(a) 605.3 m (b) 600 m

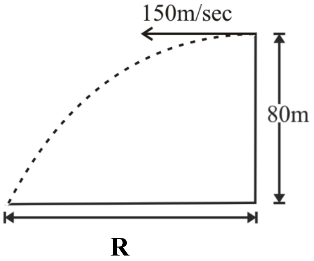
(c) 80 m (d) 230 m

BCECE-2004

Ans. (b) : Given,

Speed of aeroplane = 150m / s

Height of the plane from the surface = 80m



$$h_y = u_y t + \frac{1}{2}a_y t^2$$

$$80 = 0 + \frac{1}{2}gt^2$$

$$t^2 = \frac{80\times 2}{10}$$

$$t = 4\,\text{sec}$$

So, range covered by bomb,

R = vt = 150 × 4 = 600 m

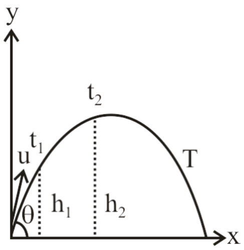
406. A cricket ball thrown across a field is at heights h_1 and h_2 from the point of projection at times t_1 and t_2 respectively after the throw. The ball is caught by a fielder at the same height as that of projection. The time of flight of the ball in this journey is

(a) $\frac{h_1t_2^2 - h_2t_1^2}{h_1t_2 - h_2t_1}$ (b) $\frac{h_1t_1^2 - h_2t_2^2}{h_2t_1 + h_1t_2}$

(c) $\frac{h_1t_2^2 + h_2t_1^2}{h_1t_2 + h_2t_1}$ (d) $\frac{h_1t_1^2 - h_2t_2^2}{h_1t_1 - h_2t_2}$

WBJEE -2014

Ans. (a) :



For vertical movement of the ball is –

$$h_1 = (u\sin\theta)t_1 - \frac{1}{2}gt_1^2$$

$$t_1 = \frac{h_1 + \frac{1}{2}gt_1^2}{u\sin\theta} \qquad ....(i)$$

Similarly for second ball

$$h_2 = (u\sin\theta)t_2 - \frac{1}{2}gt_2^2$$

$$t_2 = \frac{h_2 + \frac{1}{2}gt_2^2}{u\sin\theta} \qquad ....(ii)$$

@apna_pdf

On dividing equation (i) and (ii),

$$\frac{t_2}{t_1} = \left(\frac{h_2 + \frac{1}{2}gt_2^2}{h_1 + \frac{1}{2}gt_1^2}\right)$$

$$h_1t_2 + \frac{1}{2}gt_1^2t_2 = h_2t_1 + \frac{1}{2}gt_1t_2^2$$

$$h_1t_2 - h_2t_1 = \frac{g}{2}\left(t_1t_2^2 - t_1^2t_2\right)$$

$$\frac{g}{2} = \left(\frac{h_1t_2 - h_2t_1}{t_1t_2^2 - t_1^2t_2}\right) \qquad \text{....(iii)}$$

The time of flight of the ball,

$$T = \frac{2u\sin\theta}{g} = \frac{2}{g}(u\sin\theta)$$

From equation (i),

$$T = \frac{2}{g}\left[\frac{h_1 + \frac{1}{2}gt_1^2}{t_1}\right] \Rightarrow T = \frac{2}{t_1}\left[\frac{h_1}{g} + \frac{t_1^2}{2}\right]$$

$$= \frac{h_1}{t_1} \times \frac{2}{g} + t_1 = \frac{h_1}{t_1} \times \left(\frac{t_1t_2^2 - t_1^2t_2}{h_1t_2 - h_2t_1}\right) + t_1 \qquad \text{(from (iii))}$$

$$= \frac{h_1t_1t_2^2 - h_1t_1^2t_2 + h_1t_1^2t_2 - h_2t_1^3}{t_1(h_1t_2 - h_2t_1)} \Rightarrow T = \left(\frac{h_1t_2^2 - h_2t_1^2}{h_1t_2 - h_2t_1}\right)$$

407. A ball is projected horizontally with a velocity of 5 m/s from the top of a building 19.6 m high. How long will the ball take to hit the ground?

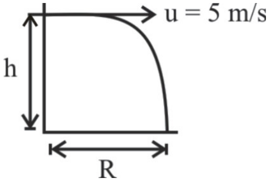
(a) $\sqrt{2}$ s (b) 2 s

(c) $\sqrt{3}$ s (d) 3 s

WBJEE -2010

Ans. (b) : Given, u = 5 m/s, h = 19.6 m, g = 9.8 m/s^2

The time taken to hit the ground is given by,

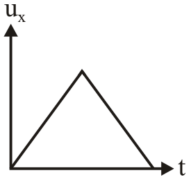


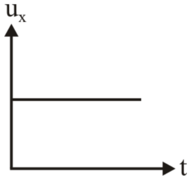
$$T = \sqrt{\frac{2h}{g}}, \quad T = \sqrt{\frac{2 \times 19.6}{9.8}}$$

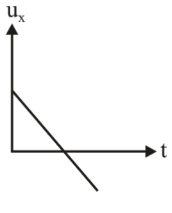
$$T = \sqrt{4}$$

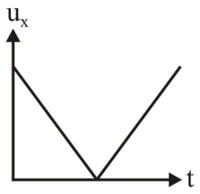
T = 2 second

408. In case of projectile motion, which one of the following figures represent variation of horizontal component of velocity (u_x) with time t? (assume that air resistance is negligible)

(a)


(b)


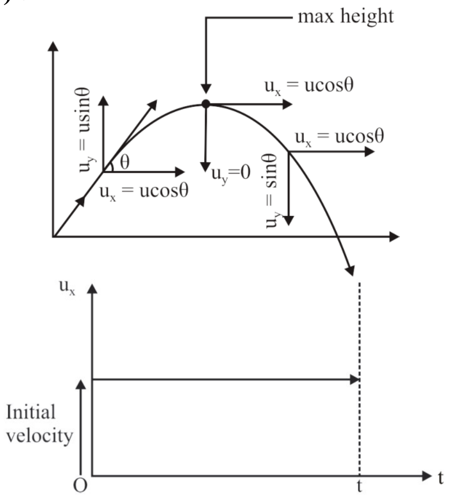
(c)


(d)


WB JEE 2021

UP CPMT-2010

Ans. (b) :



409. Two particles A and B having different masses are projected from a tower with same speed. A is projected vertically upward and B vertically downward. On reaching the ground

(a) velocity of A is greater than that of B

(b) velocity of B is greater than that of A

(c) both A and B attain the same velocity

(d) the particle with the larger mass attains higher velocity

WB JEE 2015

Ans. (c) : A is projected with a vertical speed after sometime it comes on the same level with same speed as it was projected. Now, the downward speeds of A and B at the level – x is same.

So, both A and B attain the same velocity.

410. A body is projected from the ground with a velocity $v = (3\hat{i} + 10\hat{j})\,ms^{-1}$. The maximum height attained and the range of the body respectively are (given g = 10 ms^{-2})

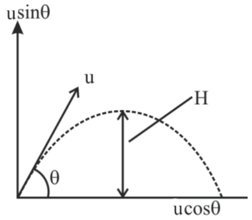
(a) 5 m and 6 m (b) 3 m and 10 m

(c) 6 m and 5 m (d) 3 m and 5 m

WB JEE 2013

Ans. (a) : Given that,

$$v = (3\hat{i} + 10\hat{j})\,m/s --- (i)$$



@apna_pdf

$$H = \frac{u^2\sin^2\theta}{2g}$$

$$\vec{v} = (u\cos\theta)\hat{i} + (u\sin\theta)\hat{j} \text{ m/s} \qquad ....(ii)$$

From eq^n (i) & (ii),

$u\cos\theta = 3$ m/s

$u\sin\theta = 10$ m/s

So, $H = \frac{u^2\sin^2\theta}{2g} = \frac{(10)^2}{2\times 10} = 5$ m (at max. H, $\theta = 90^o$)

And, $R = \frac{u^2\sin 2\theta}{g} = \frac{u^2 2\sin\theta\cos\theta}{g}$

$= \frac{2u\sin\theta \times u\cos\theta}{g}$

$= \frac{2\times 10\times 3}{10}$

$\boxed{R = 6 \text{ m}}$

Hence, H = 5 m, R = 6 m

411. A particle is projected from the ground with a kinetic energy E at an angle of 60° with the horizontal. Its kinetic energy at the highest point of its motion will be

(a) $E/\sqrt{2}$ (b) E/2

(c) E/4 (d) E/8

WB JEE-2012, 2009, 2007

Ans. (c): Given, projected angle (θ) = 60°

We know

$$E = \frac{1}{2}mv^2$$

At the highest point vertical component of velocity will be zero, only horizontal component will remain. Then horizontal component = $v\cos 60^o = \frac{v}{2}$

Velocity become half then energy become E/4

412. During projectile motion, the horizontal velocity

(a) first increases then decreases

(b) first decreases then increases

(c) always increases

(d) always constant

UP CPMT-2007

Ans. (d): During projectile motion, the horizontal velocity is always constant.

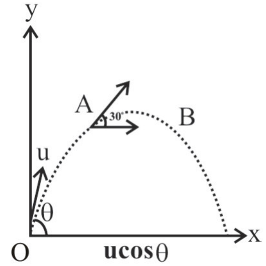
413. Two seconds after projection a projectile is travelling in a direction inclined at 30° to the horizontal after one more second, it is travelling horizontally, the magnitude and direction of its velocity are

(a) $2\sqrt{20}$ m/s, 60° (b) $20\sqrt{3}$ m/s, 60°

(c) $6\sqrt{40}$ m/s, 30° (d) $40\sqrt{6}$ m/s, 30°

UP CPMT-2014

Ans. (b) :



Let in 2 sec body reaches up to point A after one more sec up to point B.

Total time of ascent for a body = 3 sec.

$$t = \frac{u\sin\theta}{g} = 3$$

∴ $u\sin\theta = 10 \times 3 = 30$ ....(i)

Horizontal component of velocity remains always constant,

$u\cos\theta = v\cos 30^o$ ....(ii)

From vertical upward motion between O and A,

$v\sin 30^o = u\sin\theta - g\times t$

$v\sin 30^o = 30 - 10\times 2$

∴ $\frac{v}{2} = 10 \text{ ms}^{-1}$

$v = 20$ m/s

Substituting the value in Eq. (ii),

$u\cos\theta = 20\cos(30)^o = 10\sqrt{3}$ .... (iii)

From Equation (i) and (iii),

$u = 20\sqrt{3}$ m/s

and $\theta = 60^o$

414. Two particles are projected upwards with the same initial velocity v_0 in two different angles of projection such that their horizontal ranges are the same. The ratio of the heights of their highest point will be

(a) $\tan^2\theta_1$ (b) $v_0^2\sin^2\theta_1$

(c) $v_0\sin\theta_1$ (d) $v_0\cos\theta_1$

(where, θ_1 is the angle of projection of the first particle)

UP CPMT-2013

Ans. (a): As the Horizontal ranges are the same.

$$\frac{v_0^2\sin 2\theta_1}{g} = \frac{v_0^2\sin(\pi - 2\theta_2)}{g}$$

So, $\sin 2\theta_1 = \sin(\pi - 2\theta_2)$

$2\theta_1 = \pi - 2\theta_2$

$\theta_1 + \theta_2 = \frac{\pi}{2}$

$\theta_2 = \frac{\pi}{2} - \theta_1$

$$(h_1)_{max} = \frac{v_0^2\sin^2\theta_1}{2g}$$

$$(h_2)_{max} = \frac{v_0^2\sin^2\theta_2}{2g}$$

@apna_pdf

$$\frac{(h_1)_{max}}{(h_2)_{max}} = \frac{\sin^2\theta_1}{\sin^2\theta_2} = \frac{\sin^2\theta_1}{\sin^2\left(\frac{\pi}{2}-\theta_1\right)} = \frac{\sin^2\theta_1}{\cos^2\theta_1}$$

$$\frac{(h_1)_{max}}{(h_2)_{max}} = \tan^2\theta_1$$

415. A projectile thrown with a speed v at an angle θ has a range R on the surface of the earth. For same value of v and θ, its range on the surface of the moon, will be

(a) 6R (b) $\frac{R}{6}$

(c) 36R (d) $\frac{R}{36}$

UP CPMT-2011

Ans. (a) : For a projectile motion – If projectile thrown with a speed of v and at an angle θ,
We know that range is given by

$$R = \frac{v^2\sin 2\theta}{g}$$

At moon let range = R_1 and (given that v,θ are same) then range will be

$$R_1 = \frac{v^2\sin 2\theta}{g'} \quad \{g' \text{is gravity at moon}\}$$

$$g' = \frac{1}{6g} \quad \because \text{(gravity at the moon surface is about } {}^{1}\!/_{6} \text{ of that on earth)}$$

$$R_1 = \frac{v^2\sin 2\theta}{g/6}$$

$$R_1 = 6\left(\frac{v^2\sin 2\theta}{g}\right)$$

$R_1 = 6R$.

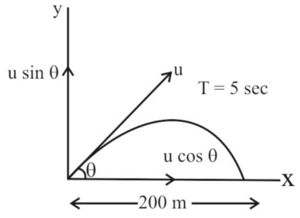
416. An arrow is shot into air, its range is 200 m and its time of flight is 5 s. If g = 10m/s², then the horizontal component of velocity of the arrow is

(a) 12.5 m/s (b) 25 m/s

(c) 31.25 m/s (d) 40 m/s

UP CPMT-2005

Ans. (d) :



Here,

$$\text{Time of flight (T)} = \frac{2u\sin\theta}{g} = 5 \text{ sec.}$$

$$\text{Range (R)} = \frac{u^2\sin 2\theta}{g} = 200 \text{ m}$$

Then,

$$R = \frac{2u\sin\theta}{g} \times u\cos\theta$$

$$R = u\cos\theta \times T = u_x \times T \qquad (\because u\cos\theta = u_x)$$

$200 = u_x \times 5$

$$u_x = \frac{200}{5} = 40\,\text{m/s}$$

417. If maximum height and range of a projectile are same, what is the angle of projection ?

(a) 30° (b) 76°

(c) 50° (d) 90°

UP CPMT-2003

Ans. (b) : Given,
If maximum height and range of a projectile are same
We know that,

$$H_{max} = \frac{u^2\sin^2\theta}{2g}$$

$$R = \frac{u^2\sin 2\theta}{g}$$

$$\because \quad H_{max} = R$$

$$\frac{u^2\sin^2\theta}{2g} = \frac{u^2\sin 2\theta}{g}$$

$$\frac{\sin^2\theta}{2} = \sin 2\theta$$

$$\frac{\sin^2\theta}{2} = 2\sin\theta\ \cos\theta$$

$$\sin^2\theta = 4\sin\theta\ \cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = 4$$

tan θ = 4

tan θ = tan 76°

θ = 76°

418. Two projectiles of same mass have their maximum kinetic energies in the ratio 4:1 and the ratio of their maximum height is also 4:1 Then the ratio of their range is

(a) 2 : 1 (b) 4 :1

(c) 8 :1 (d) 1 :1

TS EAMCET(Medical)-2017

Ans. (b): Let us consider,
Mass of both the projectiles

$m_1 = m_2 = m$ (assume)

Ratio of maximum kinetic energy,

$$\frac{K_1}{K_2} = \frac{4}{1}$$

$$\frac{\frac{1}{2}mu_1^2}{\frac{1}{2}mu_2^2} = \frac{4}{1}$$

@apna_pdf

$$\frac{u_1^2}{u_2^2}=\frac{4}{1}\Rightarrow u_1=2u_2 \qquad ....(i)$$

Ratio of maximum height,

$$\frac{H_1}{H_2}=\frac{4}{1} \qquad \left(\because H=\frac{u^2\sin^2\theta}{2g}\right)$$

$$\frac{\frac{u_1^2\sin^2\theta_1}{2g}}{\frac{u_2^2\sin^2\theta_2}{2g}}=\frac{4}{1}$$

$$\frac{4u_2^2\sin^2\theta_1}{u_2^2\sin^2\theta_2}=\frac{4}{1}$$

$$\boxed{\theta_1=\theta_2}$$

$$\therefore \text{ Range (R)} = \frac{u^2\sin 2\theta}{g}$$

$$\frac{R_1}{R_2}=\frac{u_1^2\sin 2\theta_1}{u_2^2\sin 2\theta_2}$$

$$\frac{R_1}{R_2}=\frac{4u_2^2\sin 2\theta_1}{u_2^2\sin 2\theta_2} \qquad (\because \theta_1=\theta_2)$$

$$\frac{R_1}{R_2}=\frac{4}{1}\Rightarrow R_1:R_2=4:1$$

419. An object is thrown vertically upward with a speed of 30 m/s. The velocity of the object half-a-second before it reaches the maximum height is

(a) 4.9 m/s (b) 9.8 m/s
(c) 19.6 m/s (d) 25.1 m/s

TS EAMCET (Engg.)-2017

Ans. (a): u = 30 m/s

∵ Velocity of the body half second before reaches max height = velocity of the body half second after reaches max height

$$=0+gt$$

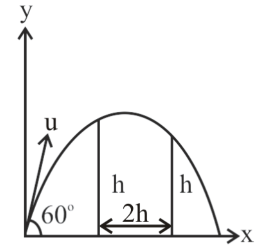
$$=9.8\times\frac{1}{2}=4.9\,\text{m/s}$$

420. A particle is projected with velocity $2\sqrt{gh}$ and at an angle 60° to the horizontal so that it just clears two walls of equal height 'h' which are at a distance 2h from each other. The time taken by the particle to travel between these two walls is

(a) $2\sqrt{\frac{2h}{g}}$ (b) $\sqrt{\frac{h}{2g}}$
(c) $2\sqrt{\frac{h}{g}}$ (d) $\sqrt{\frac{h}{g}}$

AP EAMCET (22.09.2020) Shift-II
TS EAMCET (Engg.)-2016

Ans. (c): Given, $u=2\sqrt{gh}$, $\theta=60°$



The horizontal component will be –

$$u_x=2\sqrt{gh}\cos 60^\circ=2\sqrt{gh}\left(\frac{1}{2}\right)=\sqrt{gh}$$

And the vertical component will be –

$$u_y=2\sqrt{gh}\sin 60^\circ=2\sqrt{gh}\left(\frac{\sqrt{3}}{2}\right)=\sqrt{3gh}$$

The distance between two walls is 2h. Let time taken to cross both the walls be t. Then, the speed with which it cover this distance is $\sqrt{gh}$.

So, $$\text{time}=\frac{\text{distance}}{\text{speed}}=\frac{x}{u_x}$$

$$t=\frac{2h}{\sqrt{gh}}=2\sqrt{\frac{h}{g}}$$

421. Three bodies A, B and C projected with the same initial speed with angles of projections 30°, 45° and 60° respectively. The body/bodies having maximum range

(a) C (b) B
(c) A (d) A and B

TS EAMCET(Medical)-2015

Ans. (b) : Given, Projection angle of A, B & C is 30°, 45° & 60° respectively.

We know that in projectile motion,

$$\text{Range (R)}=\frac{u^2\sin 2\theta}{g}$$

∴ Range will be max at θ = 45° since max value of sine is 1.

Therefore, body B have maximum range.

422. For a projectile if α is the angle of projection, R is the range, h is the maximum height, T is the time of flight then

(a) $\tan\alpha=\frac{R}{2h}, h=\frac{gT^2}{8}$

(b) $\tan\alpha=\frac{R}{4h}, h=\frac{gT^2}{8}$

(c) $\tan\alpha=\frac{4h}{R}, h=\frac{gT^2}{8}$

(d) $\tan\alpha=\frac{4h}{R}, h=\frac{gT^2}{4}$

TS EAMCET 20.07.2022, Shift-I

@apna_pdf

Ans. (c) : For a projectile, we know that,

Range (R) = $\dfrac{u^2 \sin 2\alpha}{g}$ ......(i)

Height (h) = $\dfrac{u^2 \sin^2\alpha}{2g}$ ......(ii)

Time of flight (T) = $\dfrac{2u \ \sin \alpha}{g}$ ......(iii)

From equation (i) and (ii), we get–

$$R = \frac{4h}{\tan\alpha} \Rightarrow \tan\alpha = \frac{4h}{R}$$

Now, from (ii) and (iii), we get–

$$h = \frac{u^2 \sin^2\alpha}{2g} \times \frac{4}{4} \times \frac{g}{g}$$

$$h = \frac{gT^2}{8}$$

423. A ball projected up passes the same height H at 2 s and 10 s. The value of H is [Use g = 9.8 m/s^2]

(a) 102 m (b) 100 m
(c) 98 m (d) 9.8 m

TS EAMCET 20.07.2022, Shift-I

Ans. (c) : If t_1 & t_2 are the time when the body is at the same height. Then,

$$h = \frac{1}{2} g t_1 t_2$$

$$h = \frac{1}{2} \times 9.8 \times 2 \times 10$$

h = 98 m

424. A football is kicked off with a velocity of 147 m/s at an angle of 30^o with the ground. The time the ball takes to touch the ground is $(g = 9.8 m/s^2)$

(a) 7.5s (b) 15s
(c) 21s (d) 26s

TS EAMCET 31.07.2022, Shift-II

Ans. (b) : Given, $u_0 = 147$ m/s, $\theta = 30^o$

Time taken to reach the ground by a projectile motion is given by

$$T = \frac{2u_0 \sin\theta}{g}$$

u_0 = projected velocity
θ = projected angle
g = gravitational acceleration

$$T = \frac{2 \times 147 \times \sin 30^o}{9.8}$$

$$= \frac{2 \times 147 \times \frac{1}{2}}{9.8}$$

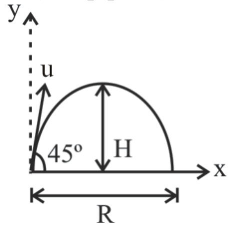
= 15s

425. A ball initially at rest is thrown vertically up with some speed and reaches height H. The ball is thrown with the same speed at an angle 45° with horizontal. The horizontal distance covered by the ball is

(a) H (b) 2H
(c) 3H (d) 4H

TS EAMCET 30.07.2022, Shift-I

Ans. (b): Given,
Initial velocity = u
Final velocity v = 0 (at top point)



$v^2 = u^2 - 2gH$
$0 = u^2 - 2gH$
$u = \sqrt{2gH}$

∴ Horizontal distance,

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{2gH \sin(2\times 45°)}{g} = \frac{2gH \times 1}{g}$$

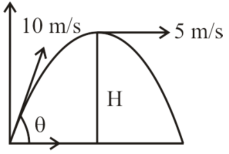
R = 2H

426. A ball is thrown at some angle with the horizontal and at speed 10 m/s. The speed of the ball at its maximum height H during the motion is 5 m/s. The magnitude of H is (Assume g = 10 m/s^2)

(a) 3.75 m (b) 4.0 m
(c) 6.5 m (d) 2.75 m

TS EAMCET 08.05.2019, Shift-I

Ans. (a) : Given that, u = 10 m/s, g = 10 m/s^2



Maximum height reached,

$$H = \frac{u^2 \sin^2\theta}{2g}$$

For velocity in horizontal direction,

$10\cos\theta = 5$

$\cos\theta = \dfrac{1}{2}$

$\theta = 60^o$

$$\therefore \quad H = \frac{10 \times 10 \left(\frac{\sqrt{3}}{2}\right)^2}{2g}$$

$$H = \frac{100 \times 3}{4 \times 2 \times 10}$$

$H = \dfrac{15}{4}$, H = 3.75 m

@apna_pdf

427. A particle is projected from a point on the ground with initial velocity of magnitude 10m/s, such that its horizontal range is maximum. The magnitude of its average velocity during its ascent is

(a) $\frac{5}{\sqrt{2}}\text{m/s}$ (b) $\frac{2\sqrt{2}}{\sqrt{5}}\text{m/s}$

(c) $\frac{5\sqrt{5}}{\sqrt{2}}\text{m/s}$ (d) $\frac{5\sqrt{5}}{2}\text{m/s}$

TS EAMCET 29.09.2020, Shift-I

Ans. (c) :

$$\text{Avg. velocity} = \frac{D}{T/2} = \frac{2D}{T}$$

$$D = \sqrt{H^2 + (R/2)^2}$$

$$\text{Avg. velocity} = 2\frac{\sqrt{H^2 + (R/2)^2}}{T}$$

For maximum horizontal range , $\theta = 45°$

$$H = \frac{u^2}{4g},\quad R = \frac{u^2}{g},\quad T = \frac{\sqrt{2}u}{g}$$

$$\therefore \quad \text{Avg. velocity} = 2\frac{\sqrt{\left(\frac{u^2}{4g}\right)^2 + \left(\frac{u^2}{2g}\right)^2}}{\frac{\sqrt{2}u}{g}}$$

$$= 2\frac{\sqrt{u^4/16g^2 + u^4/4g^2}}{\frac{\sqrt{2}u}{g}}$$

$$= 2\frac{\frac{u^2}{g}\sqrt{\frac{1}{16}+\frac{1}{4}}}{\frac{\sqrt{2}u}{g}}$$

$$= \sqrt{2}.u\sqrt{5/16}$$

$$= \frac{\sqrt{2}.u\times\sqrt{5}}{4}$$

$\because$ u = 10 m/s.

$$\text{Avg. velocity (v)} = \frac{\sqrt{2}\times 10\times\sqrt{5}}{4} = \frac{5\sqrt{5}}{\sqrt{2}}\text{m/s}$$

428. A particle aimed at a target, projected at an angle 15° with the horizontal is short of the target by 10m. If the same particle projected at an angle of 45° with the horizontal then it is away from the target by 15 meters. The angle of projection to hit the target is

(a) $\frac{1}{2}\sin^{-1}\left(\frac{1}{10}\right)$ (b) $\frac{1}{2}\sin^{-1}\left(\frac{3}{10}\right)$

(c) $\frac{1}{2}\sin^{-1}\left(\frac{9}{10}\right)$ (d) $\frac{1}{2}\sin^{-1}\left(\frac{7}{10}\right)$

TS EAMCET 28.09.2020, Shift-I
AP EAMCET - 2015

Ans. (d) : According to the question,

$R_1 = R-10$

$R_2 = R+15$

We know that,

Range $\propto$ sin2θ

$$\text{So,}\quad \frac{R-10}{R+15} = \frac{\sin 2\theta_1}{\sin 2\theta_2} = \frac{\sin 30^o}{\sin 90^o}$$

$$\frac{R-10}{R+15} = \frac{1}{2}$$

2R–20=R+15

R=35

For the range to be maximum,

sin (2 × 45°) = sin 90° =1

$$50 = R_{max} = \frac{u^2}{g}$$

$$u^2 = 50g$$

Where, θ = angle of projection

$$R = \frac{u^2\sin 2\theta}{g},\ R = 35 = \frac{50g.\sin 2\theta}{g}$$

50 sin 2θ = 35

$$\sin 2\theta = \frac{35}{50}$$

$$\sin 2\theta = \frac{7}{10}$$

$$2\theta = \sin^{-1}\left(\frac{7}{10}\right)$$

$$\theta = \frac{1}{2}\sin^{-1}\left(\frac{7}{10}\right)$$

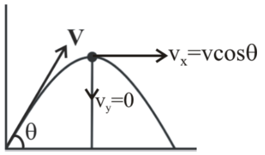
429. A projectile is thrown at a speed v, making an angle θ with the horizontal. If the speed at the maximum height is $\frac{v}{5}$, then the magnitude of θ is

(a) 30.5° (b) 60.5°

(c) 78.5° (d) 89.5°

TS EAMCET 28.09.2020, Shift-II

Ans. (c) : Given, projected velocity = v, angle of projection = θ



At H_{max} : Horizontal component of velocity $v_x = v\cos\theta$

Vertical component of velocity $v_y = 0$

But at H_{max}, $v_x = v/5$

$$\therefore \quad \frac{v}{5} = v\cos\,\theta$$

0.2 = cos θ

$v_y = 0$

$\theta = \cos^{-1}(0.2)$

= 78.46 ⇒ □ 78.50°

@apna_pdf

430. A ball is thrown with an initial velocity of 100 m/s at an angle of 30º above the horizontal. The distance from the throwing point to the point where the ball attains its original level is approximately.

(a) 860 m (b) 510 m

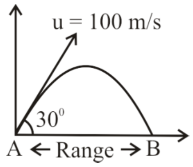
(c) 1720 m (d) 430 m

TS EAMCET 03.05.2018, Shift-I

Ans. (a): Given that,

Initial velocity = 100 m/s

Angle = 30^o



Let, A is thrown point and B is final point

Then, required distance = Range(R)

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$= \frac{(100)^2 \sin 60^o}{10} = \frac{10000 \times \frac{\sqrt{3}}{2}}{10}$$

$R = 865 \text{ m} \approx 860 \text{ m}$

431. A projectile is thrown at a speed which is twice its speed at its maximum height. If R and H are its range and maximum height respectively then the ratio $\frac{R}{H}$ is:

(a) $\frac{4}{\sqrt{3}}$ (b) $\frac{\sqrt{3}}{8}$

(c) 2 (d) $2\sqrt{3}$

TS EAMCET 05.08.2021, Shift-II

Ans. (a): Only horizontal component of velocity is present at highest point which is equal to,

$2u\cos\theta = u$

$\cos\theta = \frac{1}{2}$

$\cos\theta = \cos 60°$

$\theta = 60°$

We know,

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$= \frac{u^2 \sin 120°}{g} = \frac{u^2 \sin(90° + 30°)}{g} = \frac{u^2 \cos 30°}{g}$$

$$R = \frac{u^2 \times \frac{\sqrt{3}}{2}}{g} = \frac{u^2\sqrt{3}}{2g}$$

$$H = \frac{u^2 \sin^2 \theta}{2g} = \frac{u^2 (\sin 60°)^2}{2g}$$

$$H = \frac{u^2 \left(\frac{\sqrt{3}}{2}\right)^2}{2g} = \frac{u^2 \times 3}{8g} = \frac{3u^2}{8g}$$

$$\therefore \frac{R}{H} = \frac{u^2\sqrt{3}/2g}{3u^2/8g} = \frac{\sqrt{3}}{2} \times \frac{8}{3} = \frac{4}{\sqrt{3}}$$

$$\frac{R}{H} = \frac{4}{\sqrt{3}}$$

432. A projectile object is thrown in the upward direction making an angle of 60º with the horizontal with velocity of 140m/s. Then the time after which its velocity makes an angle 30º with the horizontal is (use g= 10 m/s^2)

(a) $\frac{14}{\sqrt{3}}$s (b) $7\sqrt{3}$s

(c) $14\sqrt{3}$s (d) $\frac{7}{\sqrt{3}}$s

TS EAMCET 06.08.2021, Shift-II

Ans. (a) : Given,

Angle = 30^o

$g = 10 \text{ m/s}^2$, $u = 140$m/s

Let v be the velocity at inclination 30º with horizontal and horizontal velocity remains constant.

So, 140 cos 60º = v cos 30º

$$\therefore v = 140 \times \frac{1}{2} \times \frac{2}{\sqrt{3}}.$$

$$v = \frac{140}{\sqrt{3}} \text{ m/s}$$

Along y-direction,

$v_y = u_y - gt$

$$\frac{140}{\sqrt{3}} \sin 30º = 140 \sin 60º - 10t$$

$$t = \frac{14}{\sqrt{3}} \text{ sec.}$$

433. A particle is projected horizontally with a speed 15 ms^{-1} at a height 200 m above the ground at time t = 0. What is the tangential acceleration of the particle at time t = 2 sec? Assume g = 10 m s^{-2}.

(a) 6 m s^{-2} (b) 8 m s^{-2}

(c) 10 m s^{-2} (d) 12 m s^{-2}

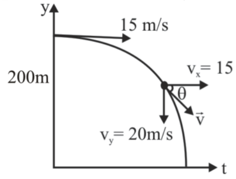
SRM JEE - 2008

Ans. (b) : Given that,

$u_x = 15$m/s, h = 200m

$u_y = 0$, $a_x = 0$, $a_y = g$

Velocity of the particle in x and y direction at t = 2 s



@apna_pdf

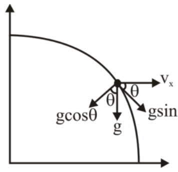
$v_x = u_x = 15\text{m/s}$

$v_y = \frac{1}{2}gt^2 = \frac{1}{2}\times 10(2)^2$

$v_y = 20\text{m/s}$

Now, $\tan\theta = \frac{v_y}{v_x} = \frac{20}{15} = \frac{4}{3} = \frac{\text{Perpendicular}}{\text{Base}} \Rightarrow \sin\theta = \frac{4}{5}$

Also the component of the acceleration at t = 2 s is shown in the figure



The tangential acceleration at t = 2 s is

$a_t = g\sin\theta$

$= 10\times\frac{4}{5} = 8\text{m/s}^2 \qquad \left[\because \sin\theta = \frac{4}{5}\right]$

434. When projected at an angle of 15°, the range of a projectile is 50 m. If with the same speed, it is projected at an angle of 45°, its range will be

(a) 150 m (b) 100 m

(c) 50 m (d) 25 m

SRM JEE - 2011

Ans. (b) : Given that,

$\theta_1 = 15°, R_1 = 50\text{ m}, \theta_2 = 45°, R = ?$

Range of a projectile is $(R) = \frac{u^2\sin 2\theta}{g}$

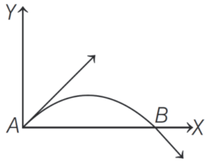
$$50 = \frac{u^2\sin 30°}{g} \qquad \ldots \text{(i)}$$

$$R_2 = \frac{u^2\sin 90°}{g} \qquad \ldots \text{(ii)}$$

Dividing eq. (i) by eq. (ii), we get

$$\frac{50}{R_2} = \frac{1}{2} \Rightarrow R_2 = 100\text{m}$$

435. The velocity of a projectile at the initial point A is $(2\hat{i}+3\hat{j})$ m/s. Its velocity (in m/s) at point B is

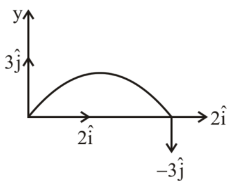


(a) $-2\hat{i}-3\hat{j}$ (b) $-2\hat{i}+3\hat{j}$

(c) $2\hat{i}-3\hat{j}$ (d) $2\hat{i}+3\hat{j}$

[NEET 2013]

Ans. (c):



Velocity at $A(v_A) = (2\hat{i}-3\hat{j})\text{m/s}$

From figure horizontal velocity component at A and B is same in magnitude and direction.

Vertical component at A and B are opposite in direction.

So, velocity at point $B(v_B) = (2\hat{i}-3\hat{j})\text{m/s}$

436. A particle of mass m is projected with velocity v making an angle of 45° with the horizontal. When the particle lands on the level ground, the magnitude of the change in its momentum will be

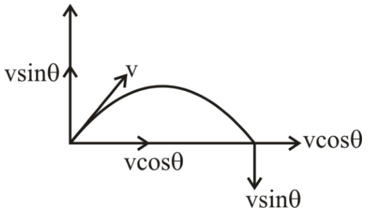
(a) 2 mv (b) $\frac{mv}{\sqrt{2}}$

(c) $mv\sqrt{2}$ (d) zero

[AIPMT 2008]

Ans. (c): Mass of particle = m

Angle of projection (θ) = 45°



$v_1 = (v\cos\theta)\hat{i} + (v\sin\theta)\hat{j}$

$v_2 = (v\cos\theta)\hat{i} - (v\sin\theta)\hat{j}$

$\Delta p = m(v_2 - v_1) = 2mv\sin\theta\,\hat{j}$

$= 2mv\sin(45°) = \sqrt{2}\,mv$

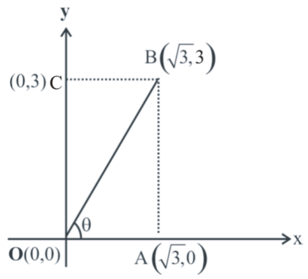
437. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its co-ordinates at a later time are $(\sqrt{3}, 3)$. The path of the particle makes with the x-axis an angle of

(a) 30° (b) 45°

(c) 60° (d) 0°

[AIPMT 2007]

Ans. (c) :



$\tan\theta = \frac{AB}{OA}$

$= \frac{3}{\sqrt{3}}$

$\tan\theta = \sqrt{3} \Rightarrow \theta = 60°$

@apna_pdf

438. For angles of projection of a projectile at angles $(45^o - \theta)$ and $(45^o + \theta)$, the horizontal ranges described by the projectile are in the ratio of

(a) 1:1 (b) 2:3

(c) 1:2 (d) 2:1

JEE Main-26.07.2022, Shift-II
AIPMT-2006, 2000, 1990

Ans. (a): Let initial velocity = u

Given: Angle of projection $\theta_1 = (45^o - \theta)$

$\theta_2 = (45^o + \theta)$

$$\text{Range } R_1 = \frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin(90^o - 2\theta)}{g}$$

$$R_2 = \frac{u^2 \sin 2\theta_2}{g} = \frac{u^2 \sin(90^o + 2\theta)}{g}$$

$$\text{So, } \frac{R_1}{R_2} = \frac{\sin(90^o - 2\theta)}{\sin(90^o + 2\theta)} = \frac{\cos 2\theta}{\cos 2\theta} = \frac{1}{1}$$

$R_1 : R_2 = 1 : 1$

439. A projectile is fired from the surface of the earth with a velocity of 5 ms^{-1} at angle θ with the horizontal. Another projectile fired from another planet with a velocity of 3 ms^{-1} at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is (in ms^{-2}) is (given, g = 9.8 ms^{-2})

(a) 3.5 (b) 5.9

(c) 16.3 (d) 110.8

[AIPMT 2014]

Ans. (a) : Projectile velocity fired from the earth surface $(u_1) = 5m/s$

Angle of projection = θ

$g_1 = 9.8 \text{ m/s}^2$

Projectile velocity fired from another plant $(u_2) = 3m/s$

Angle of projection = θ

Let acceleration due to gravity on plant = g_2 m/s^2

Trajectory of both projectile are identical so range are equal.

$R_1 = R_2$

$$\frac{u_1^2 \sin 2\theta}{g_1} = \frac{u_2^2 \sin 2\theta}{g_2}$$

$$\frac{(5)^2}{9.8} = \frac{(3)^2}{g_2}$$

$$g_2 = \frac{9 \times 9.8}{25}$$

$g_2 = 3.52 \text{ m/s}^2$

440. A ball is projected with a velocity, 10 ms^{-1}, at an angle of 60^0 with the vertical direction. Its speed at the highest point of its trajectory will be

(a) $5 ms^{-1}$ (b) $10 ms^{-1}$

(c) Zero (d) $5\sqrt{3} ms^{-1}$

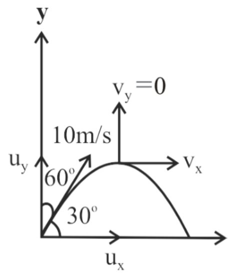
NEET UG -2022

Ans. (d) : Initial velocity of ball (u) = 10m/s

Angle with vertical = 60^o

So, Angle with horizontal (θ) = 90 – 60 = 30^o

$\theta = 30^o$



At highest point of trajectory $v_y = 0$

Horizontal velocity remains same at highest point

Velocity of ball $v_x = u \cos 30^o = 10 \cos 30^o$

$$v_x = 10 \times \frac{\sqrt{3}}{2} = 5\sqrt{3} \text{ m/s}$$

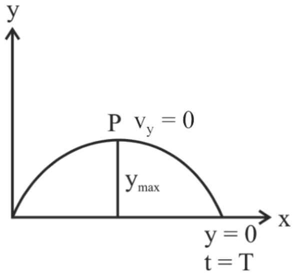
441. A projectile move from the ground such that its horizontal displacement is x = Kt and vertical displacement is y = Kt (1 – αt), where K and α are constants and t is time. Find out total time of flight (T) and maximum height attained (Y_{max}) its

(a) $T = \alpha, \; Y_{max} = \frac{K}{2\alpha}$ (b) $T = \frac{1}{\alpha}, \; Y_{max} = \frac{2K}{\alpha}$

(c) $T = \frac{1}{\alpha}, \; Y_{max} = \frac{K}{6\alpha}$ (d) $T = \frac{1}{\alpha}, \; Y_{max} = \frac{K}{4\alpha}$

MP PET-2008

Ans. (d) :



Horizontal displacement (x) = Kt

Vertical displacement (y) = Kt (1 – αt)

For total time of flight T displacement in y direction will be zero

y = 0

∴ $0 = Kt(1 - \alpha t)$

$t = \frac{1}{\alpha}$ (t = 0 not possible)

$T = \frac{1}{\alpha}$

(ii) Maximum height y_{max}

At maximum height point P velocity in y direction will be zero

$$v_y = 0 \quad \text{and} \quad \frac{dy}{dt} = v_y$$

@apna_pdf

$\therefore \quad \frac{dy}{dt} = 0$

$$\frac{d}{dt}[Kt - \alpha t^2 K] = 0$$

$$K - 2\alpha Kt = 0$$

$$t = \frac{1}{2\alpha}$$

$$y = Kt(1 - \alpha t)$$

$$y_{max} = K\left(\frac{1}{2\alpha}\right)\left(1 - \frac{\alpha}{2\alpha}\right)$$

$$\boxed{y_{max} = \frac{K}{4\alpha}}$$

442. A body is projected vertically upwards. The times corresponding to height h while ascending and while descending are t_1 and t_2, respectively.

Then, the velocity of projection will be (take g as acceleration due to gravity)

(a) $\frac{g\sqrt{t_1 t_2}}{2}$ (b) $\frac{g(t_1 + t_2)}{2}$

(c) $g\sqrt{t_1 t_2}$ (d) $g\frac{t_1 t_2}{(t_1 + t_2)}$

JIPMER-2017

Ans. (b) : In case of motion under gravity time taken to go up is equal to the time taken to fall down through the same distance.

Here, Initial velocity = u, a = –g, s = h,

Time = t

$$s = ut + \frac{1}{2}at^2$$

$$h = ut + \frac{1}{2}(-g)t^2$$

$$\Rightarrow gt^2 - 2ut + 2h = 0$$

$$\therefore \quad \text{Time, } t = \frac{u \pm \sqrt{u^2 - 2gh}}{g}$$

It means t has two values i.e

$$t_1 = \frac{u - \sqrt{u^2 - 2gh}}{g}$$

$$t_2 = \frac{u + \sqrt{u^2 - 2gh}}{g}$$

$$\text{Total time, } t_1 + t_2 = \frac{2u}{g}$$

$$u = \frac{g(t_1 + t_2)}{2}$$

443. Velocity-time curve for a body projected vertically upwards is

(a) Parabola (b) Ellipse

(c) Hyperbola (d) Straight line

JIPMER-2011

Ans. (d) : Velocity–time curve for a body projected vertically upward is a straight line because the acceleration due to gravity is constant and opposite to the direction of initial velocity.

$v = u_0 - gt$, which is a straight line with slope negative.

444. Diwali rocket is ejecting 50 g of gases/s at a velocity of 400 m/s. The accelerating force on the rocket will be

(a) 22 dyne (b) 20 N

(c) 20 dyne (d) 100 N

JIPMER-2009

Ans. (b) : The accelerating force on the rocket = upward thrust.

$$\text{Given, } \frac{\Delta m}{\Delta t} = 50 \times 10^{-3}\,\text{kg/s},$$

u = 400m/s

Applying momentum conservation,

F = change in momentum

$$F = \frac{\Delta m}{\Delta t} \times \Delta u$$

So, accelerating force = $50 \times 10^{-3} \times 400 = 20$N.

445. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball?

(a) 25 m (b) 50 m

(c) 100 m (d) 200 m

JEE Main-29.06.2022, Shift-II

Ans. (b) : Range, $R = \frac{u^2 \sin 2\theta}{g}$

For max range, θ = 45°

$$R_{max} = \frac{u^2}{g} = 100\text{ m}$$

Max. height attained when ball is thrown vertically upward with velocity (u).

$$H_{max} = \frac{u^2}{2g} = \frac{100}{2} = 50\,\text{m}$$

446. An object is projected in the air with initial velocity u at an angle θ. The projectile motion is such that the horizontal range R, is maximum. Another object is projected in the air with a horizontal range half of the range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be ______ degree.

JEE Main-29.07.2022, Shift-I

Ans. (15^o) : Range, $R = \frac{u^2 \sin 2\theta}{g}$

Max. range, θ = 45°

$$R_1 = \frac{R}{2}$$

@apna_pdf

$$\frac{u^2\sin 2\theta_1}{g}=\frac{u^2\sin 2\theta}{2g}$$

$$\sin 2\theta_1=\frac{\sin 2\theta}{2}=\frac{1}{2}$$

$2\theta_1 = 30° \Rightarrow \theta_1 = 15°$

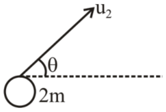
447. A ball of mass m is thrown vertically upward. Another ball of mass 2 m is thrown an angle θ with the vertical. Both the balls stay in air for the same period of time. The ratio of the heights attained by the two balls respectively is $\frac{1}{x}$. The value of x is ____.

JEE Main-27.07.2022, Shift-I

Ans. (1) :

Max. time, $T_1=\frac{2u_1}{g}, \text{Height}, H_1=\frac{u_1^2}{2g}$

$T_2=\frac{2u_2\sin\theta}{g}, H_2=\frac{u_2^2\sin^2\theta}{2g}$



According to the question,

$T_1 = T_2$

$$\frac{2u_1}{g}=\frac{2u_2\sin\theta}{g}\Rightarrow u_1=u_2\sin\theta$$

$$\because \frac{1}{x}=\frac{H_1}{H_2}=\frac{u_1^2/2g}{u_2^2\sin^2\theta/2g}=\frac{u_2^2\sin^2\theta}{u_2^2\sin^2\theta}=1$$

$$\frac{1}{x}=1 \qquad \Rightarrow x=1$$

448. A body of mass 10 kg is projected at an angle of 45^o with the horizontal. The trajectory of the body is observed to pass through a point (20, 10). If T is the time of flight, then its momentum vector, at time $t=\frac{T}{\sqrt{2}}$ is_______

[Take g=10 m/s^2]

(a) $100\hat{i}+(100\sqrt{2}-200)\hat{j}$

(b) $100\sqrt{2}\hat{i}+(100-200\sqrt{2})\hat{j}$

(c) $100\hat{i}+(100-200\sqrt{2})\hat{j}$

(d) $100\sqrt{2}\hat{i}+(100\sqrt{2}-200)\hat{j}$

JEE Main-27.07.2022, Shift-II

Ans. (d) According to question

$$y=x-\frac{10x^2}{2u^2\left(\frac{1}{2}\right)}\Rightarrow 10=20-\frac{10\times(20)^2}{u^2}$$

$u = 20$

$$T=\frac{2\times 20}{\sqrt{2}\times 10}=2\sqrt{2}$$

$$\vec{v}=10\sqrt{2}\,\hat{i}+\left[10\sqrt{2}-10(2)\right]\hat{j}$$

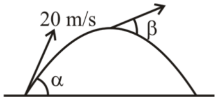
Momentum $\vec{p}=M\vec{v}=100\sqrt{2}\,\hat{i}+\left(100\sqrt{2}-200\right)\hat{j}$

449. A projectile is launched at an angle 'α' with the horizontal with a velocity 20 ms^{-1}. After 10 s, its inclination with horizontal is 'β'. The value of tanβ will be (g = 10 ms^{-2}).

(a) tanα + 5secα
(b) tanα – 5secα
(c) 2tanα – 5secα
(d) 2tanα + 5secα

JEE Main-27.06.2022, Shift-I

Ans. (b) : Given, velocity of projectile (v) = 20 m/s, time (t) = 10 s, tanβ = ?



$v_x = u_x = 20\cos\alpha$

$v_y = 20\sin\alpha - gt = 20\sin\alpha - 10 \times 10 = 20\sin\alpha - 100$

$$\tan\beta=\frac{v_y}{v_x}=\frac{20\sin\alpha-100}{20\cos\alpha}$$

$$\tan\beta=\frac{20(\sin\alpha-5)}{20\cos\alpha}=\frac{\sin\alpha-5}{\cos\alpha}$$

$\tan\beta = \tan\alpha - 5\sec\alpha$

450. A ball is projected vertically upward with an initial velocity of 50 ms^{-1} at t = 0s. At t = 2s. another ball is projected vertically upward with same velocity. At t = ——— s, second ball will meet the first ball (g = 10 ms^{-2}).

JEE Main-26.06.2022, Shift-II

Ans. (6) : Given, Initial velocity of ball = 50 m/s

Let they meet at t = t

So, first ball gets t sec

and 2nd gets (t–2) sec and they will meet at same height

$$h_1=50t-\frac{1}{2}gt^2 \qquad .....(i)$$

and $$h_2=50(t-2)-\frac{1}{2}g(t-2)^2 \qquad .....(ii)$$

$\because \quad h_1 = h_2$

Putting the value from equation (i) and (ii), we get–

$$50t-\frac{1}{2}gt^2=50(t-2)-\frac{1}{2}g(t-2)^2$$

$$50t-\frac{1}{2}gt^2=50t-100-\frac{1}{2}g(t^2+4-4t)$$

$$100=\frac{1}{2}g(t^2-t^2-4+4t)$$

$$100=\frac{1}{2}g(4t-4)$$

$200 = g(4t - 4)$

$200 = 10 \times 4(t - 1)$

$5 = t - 1$

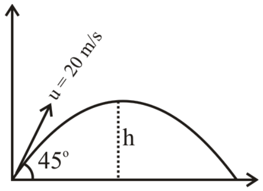
or $t = 6$ sec

451. A body is projected from the ground at an angle of 45^o with the horizontal. Its velocity after 2s is 20ms^{-1}.The maximum height reached by the body during its motion is ____ m. (use g= 10 ms^{-2})

JEE Main-24.06.2022, Shift-II

@apna_pdf

Ans. (20) : Given that, u = 20 m/s, angle (θ) = 45°, g = 10 m/s²



From maximum height of projectile, θ = 90°

$$H=\frac{u^2\sin^2\theta}{2g}$$

So, $$H=\frac{20^2\sin^2 90^\circ}{2\times10}$$

H = 20 m/s

452. If the initial velocity in horizontal direction of a projectile is unit vector $\hat{i}$ and the equation of trajectory is y = 5x (1 – x). Their component vector of the initial velocity is ______ $\hat{j}$
(Take g = 10m/s²)

JEE Main-26.07.2022, Shift-I

Ans. (5) : Given that, u_x = 1 m/sec

Let the initial velocity in vector form–

$$v=u_x\hat{i}+u_y\hat{j}$$

y = 5x (1–x)

y = 5x – 5x²

$$\frac{dy}{dt}=5\frac{dx}{dt}-5.2x.\frac{dx}{dt}$$

$$u_y=5u_x-10x.u_x$$

For initial velocity, x = 0

$u_y = 5u_x$

$u_y = 5\times 1$ $\quad[\because u_x=1\text{m}]$

u_y = 5 m/sec

So, the y component vector of the initial velocity is $5\hat{j}$.

453. To projectile thrown at 30° and 45° with the horizontal respectively, reach the maximum height in same time. The ratio of their initial velocities is

(a) $1:\sqrt{2}$ (b) 2 : 1

(c) $\sqrt{2}:1$ (d) 1 : 2

JEE Main-26.07.2022, Shift-I

Ans. (c) : Given, $\theta_1 = 30°$, $\theta_2 = 45°$

Time taken to reach maximum height–

$$T=\frac{u\sin\theta}{g}$$

$$\therefore\quad \frac{u_1\sin\theta_1}{g}=\frac{u_2\sin\theta_2}{g}$$

$$u_1\sin30^\circ=u_2\sin45^\circ$$

$$\frac{u_1}{u_2}=\frac{1/\sqrt{2}}{1/2}=\frac{\sqrt{2}}{1}$$

or $\quad u_1:u_2=\sqrt{2}:1$

454. A ball is projected from the ground with a speed 15 ms⁻¹ at an angle θ with horizontal so that its range and maximum height are equal, then tan θ will be equal to

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) 2 (d) 4

JEE Main-25.07.2022, Shift-II

Ans. (d) : Given that, speed = 15 m/s

Range = Maximum height

We know that,

$$R=\frac{u^2\sin2\theta}{g}$$

$$H=\frac{u^2\sin^2\theta}{2g}$$

$\because\quad$ R = H

$$\therefore\quad \frac{u^2\sin2\theta}{g}=\frac{u^2\sin^2\theta}{2g}$$

$$2\sin\theta\cdot\cos\theta=\frac{\sin^2\theta}{2}$$

4cosθ = sinθ

or $\quad$ tanθ = 4

455. A boy can throw a stone upto a maximum height of 10m. The maximum horizontal distance that the boy can throw the same stone upto will be

(a) $20\sqrt{2}$m (b) 10 m

(c) $10\sqrt{2}$m (d) 20 m

AIEEE-2012

Ans. (d) : For vertically projected body height

$$H=\frac{u^2}{2g}\qquad\text{....(i)}$$

For same body, horizontal distance travelled when thrown at an angle θ is–

$$R=\frac{u^2\sin2\theta}{g}$$

Maximum horizontal distance

$$R_{max}=\frac{u^2}{g}\qquad\text{....(ii)}$$

From equation (i) and (ii), we get–

R = 2H = 2 × 10 = 20 m

456. A particle of mass m is projected with a velocity v making an angle of 30° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height h is

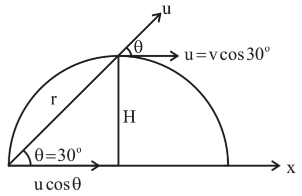
(a) $\frac{\sqrt{3}}{2}\frac{mv^2}{g}$ (b) zero

(c) $\frac{mv^3}{\sqrt{2}g}$ (d) $\frac{\sqrt{3}}{16}\frac{mv^3}{g}$

AIEEE 2011

@apna_pdf

Ans. (d) : Given that, mass of particle = m, velocity = v, angle = 30°



We know that,

Angular momentum, $\vec{L} = r \times mv$

$$|\vec{L}| = rmv\sin\theta$$

At maximum point, velocity = v cosθ = v cos 30° $= \dfrac{\sqrt{3}\,v}{2}$

The maximum height reached will be –

$$H = \frac{v^2\sin^2\theta}{2g}$$

$$H = \frac{v^2\sin^2 30^\circ}{2g} = \frac{v^2}{8g}$$

From the figure,

$$L = mvH = m \times \frac{\sqrt{3}\,v}{2} \times \frac{v^2}{8g} = \frac{\sqrt{3}\,mv^3}{16g}$$

457. Two guns A and B can fire bullets at speeds 1 km/s and 2 km/s, respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets on the ground fired by the two guns is

(a) 1 : 4 (b) 1 : 16

(c) 1 : 8 (d) 1 : 2

JEE Main-10.01.2019, Shift-I

Ans. (b) : Given that,

Initial velocity of bullet from first gun (u_A) = 1 km/s

Initial velocity of bullet from second gun (u_B) = 2 km/s

We know,

$$R = \frac{u^2\sin 2\theta}{g}$$

For gun A,

$$R_{max} = \frac{u_A^2}{g} \quad .....(i)\ (\because\ \theta = 45^\circ)$$

For gun B,

$$R_{max} = \frac{u_B^2}{g} \quad .....(ii)$$

∵ The gun fired in all possible direction that's why the shape of circle is formed whose area is πR^2.

Taking ratio between A and B, we get–

$$\frac{(R_{max})_A}{(R_{max})_B} = \frac{u_A^2}{g} \times \frac{g}{u_B^2}$$

$$\frac{(R_{max})_A}{(R_{max})_B} = \frac{1}{4}$$

or $$\frac{(\pi R_{max}^2)_A}{(\pi R_{max}^2)_B} = \frac{1}{16}$$

$$\frac{(A_1)_A}{(A_2)_B} = \frac{1}{16}$$

Thus, ratio of the maximum area are 1:16.

458. A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product t_1 t_2 is

(a) $\dfrac{R}{4g}$ (b) $\dfrac{R}{g}$

(c) $\dfrac{R}{2g}$ (d) $\dfrac{2R}{g}$

JEE Main-12.04.2019, Shift-I
AP EAMCET-2012

Ans. (d) : Given that,

Range of fired shell = R

Time of flight are t_1 and t_2

Range of projectile motion (R) = $\dfrac{u^2\sin 2\theta}{g}$

Time taken by the shell to reach the target

$$t = \frac{2u\sin\theta}{g}$$

Now, the shell hits the target in two way θ and (90 – θ)

So, for t_1

$$t_1 = \frac{2u\sin\theta}{g}$$

For t_2,

$$t_2 = \frac{2u\sin(90-\theta)}{g}$$

According to the question,

$$t_1 \times t_2 = \frac{2u\sin\theta}{g} \times \frac{2u\sin(90-\theta)}{g}$$

$$t_1 \times t_2 = \frac{4u^2\sin\theta \times \cos\theta}{g^2} \quad [\because\ \sin(90-\theta) = \cos\theta]$$

$$t_1 \times t_2 = \frac{2u^2 \times 2\sin\theta \times \cos\theta}{g^2}$$

$$t_1 \times t_2 = \frac{2u^2 \times \sin 2\theta}{g^2} \quad (\because \sin 2\theta = 2\sin\theta \times \cos\theta)$$

$$t_1 \times t_2 = \frac{2}{g}\left[\frac{u^2 \times \sin 2\theta}{g}\right]$$

$$t_1 \times t_2 = \frac{2}{g} \times R \quad \left(\because R = \frac{u^2 \times \sin 2\theta}{g}\right)$$

$$t_1 \times t_2 = \frac{2R}{g}$$

@apna_pdf

459. Two particles are projected from the same point with the same speed u such that they have the same range R, but different maximum heights h_1 and h_2. Which of the following is correct?

(a) $R^2 = 4h_1h_2$ (b) $R^2 = 16h_1h_2$

(c) $R^2 = 2h_1h_2$ (d) $R^2 = h_1h_2$

JEE Main-12.04.2019, Shift-II
BITSAT-2016, 2008
JIPMER-2016
Assam CEE-2014

Ans. (b) : Given that,

Same speed of two particle = u

Range of two particle = R

Range of projectile motion,

$$R = \frac{u^2 \sin 2\theta}{g}$$

Height for angle θ–

$$h_1 = \frac{u^2 \sin^2\theta}{2g} \quad \text{....(i)}$$

Height for angle (90–θ),

$$h_2 = \frac{u^2 \sin^2(90-\theta)}{2g} \quad \text{....(ii)}$$

multiply equation (i) and (ii), we get

$$h_1 \times h_2 = \frac{u^2 \sin^2\theta}{2g} \times \frac{u^2 \sin^2(90-\theta)}{2g}$$

So,

$$= \frac{u^2 \sin^2\theta}{2g} \times \frac{u^2 \cos^2\theta}{2g}$$

$$= \frac{u^4 \sin^2\theta \times \cos^2\theta}{4g^2} \times \frac{4}{4}$$

$$= \frac{4u^4 \sin^2\theta \times \cos^2\theta}{16g^2}$$

$$= \frac{1}{16}\left[\frac{4u^4 \sin^2\theta \times \cos^2\theta}{g^2}\right]$$

$$= \frac{1}{16}\left[\frac{2u^2 \sin\theta\cos\theta}{g}\right]^2 = \frac{1}{16}\left[\frac{u^2 \sin 2\theta}{g}\right]^2$$

$$h_1 \times h_2 = \frac{1}{16} \times R^2$$

Hence,

$$R^2 = 16\, h_1 \times h_2$$

460. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0, then (Take, $g = 10 ms^{-2}$)

(a) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} ms^{-1}$

(b) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} ms^{-1}$

(c) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} ms^{-1}$

(d) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} ms^{-1}$

JEE Main-12.04.2019, Shift-I

Ans. (c) : Given that,

Trajectory equation (y) = $2x - 9x^2$

$g = 10\ m/s^2$

angle (θ_0) = ?

velocity (v_0) = ?

We know,

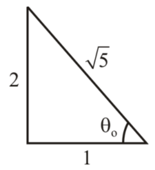
Standard equation of trajectory –

$$y = x\tan\theta - \frac{gx^2}{2v_0^2\cos^2\theta_0}$$

On comparing with equation $y = 2x - 9x^2$, we get

$$\tan\theta = \frac{\text{Perpendicular}}{\text{Base}} = 2$$

From figure,



$$\cos\theta_0 = \frac{1}{\sqrt{5}}$$

$$\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$$

From equation, $y = 2x - 9x^2$

$\tan\theta = 2$

and $$\frac{g}{2v_0^2\cos^2\theta_0} = 9$$

$$\frac{10}{2v_0^2\left(\frac{1}{\sqrt{5}}\right)^2} = 9$$

$$\frac{50}{2v_0^2} = 9$$

$$v_0^2 = \frac{25}{9}$$

$$v_0 = \frac{5}{3} m/s$$

461. The trajectory of a projectile in a vertical plane is $y = \alpha x - \beta x^2$, where α and β are constants and x and y are respectively the horizontal and vertical distances of the projectile from the point of projection. The angle of projection θ and the maximum height attained H are respectively given by

(a) $\tan^{-1}\alpha, \frac{\alpha^2}{4\beta}$ (b) $\tan^{-1}\beta, \frac{\alpha^2}{2\beta}$

@apna_pdf

(c) $\tan^{-1}\alpha, \dfrac{4\alpha^2}{\beta}$ (d) $\tan^{-1}\left(\dfrac{\beta}{\alpha}\right), \dfrac{\alpha^2}{\beta}$

JEE Main-26.02.2021, Shift-II
AP EAMCET-2014

Ans. (a) : Given that,

Trajectory of particle (y) = $\alpha x - \beta x^2$

Where, x and y are constant

maximum height = ?

Projection angle (θ) = ?

Now, $y = \alpha x - \beta x^2$

differentiate both side w.r.t x, we get

$$\frac{dy}{dx} = \alpha - 2\beta x = 0 \qquad \left(\because \frac{dy}{dx} = 0\right)$$

$$\alpha = 2\beta x$$

$$x = \frac{\alpha}{2\beta}$$

For maximum height,

$$h = \alpha x - \beta x^2$$

$$= \alpha\left(\frac{\alpha}{2\beta}\right) - \beta\left(\frac{\alpha}{2\beta}\right)^2 = \left(\frac{\alpha^2}{2\beta}\right) - \left(\frac{\alpha^2 \times \beta}{4\beta^2}\right)$$

$$= \frac{\alpha^2}{2\beta} - \frac{\alpha^2}{4\beta} = \frac{2\alpha^2 - \alpha^2}{4\beta} = \frac{\alpha^2}{4\beta}$$

$$h = \frac{\alpha^2}{4\beta}$$

Trajectory projectile motion,

$$y = x\tan\theta - \frac{gx^2}{2u^2 \cdot \cos^2\theta}$$

On comparing given equation,

$$\tan\theta = \alpha$$

$$\theta = \tan^{-1}(\alpha)$$

462. A player kicks a football with an initial speed of 25 ms^{-1} at an angle of 45° from the ground. What are the maximum height and the time taken by the football to reach at the highest point during motion ?
(Take, g = 10ms^{-2})

(a) h_{max} = 10m, T=2.5s
(b) h_{max} = 15.625m, T=3.54s
(c) h_{max} = 15.625m, T=1.77s
(d) h_{max} = 3.54 m, T=0.125s

JEE Main-27.08.2021, Shift-II

Ans. (c) : Given that,

Initial speed (u) = 25 m/s

angle = 45°

Maximum height (h_{max}) = ?

Time (t) = ?

We know,

$$\text{maximum height } (h_{max}) = \frac{u^2\sin^2\theta}{2g}$$

$$= \frac{(25)^2\sin^2 45^\circ}{2\times 10} = \frac{625\times\left(\frac{1}{\sqrt{2}}\right)^2}{20} = \frac{625\times\frac{1}{2}}{20} = \frac{312.5}{20}$$

h_{max} = 15.62m

Time taken to reach the maximum height–

$$T = \frac{u\sin\theta}{g} = \frac{25\times\sin 45^\circ}{10}$$

$$= \frac{25\times\frac{1}{1.414}}{10} \qquad \left(\because \sqrt{2} = 1.414\right)$$

$$= \frac{17.68}{10} = 1.77 \text{ sec}$$

463. A helicopter is flying horizontally with a speed v at an altitude h has to drop a food packet for a man on the ground. What is the distance of helicopter from the man when the food packet is dropped?

(a) $\sqrt{\dfrac{2ghv^2+1}{h^2}}$ (b) $\sqrt{2ghv^2+h^2}$

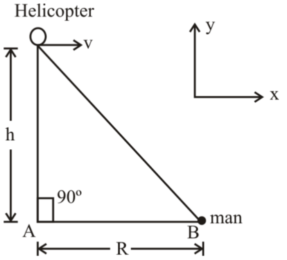
(c) $\sqrt{\dfrac{2v^2h}{g}+h^2}$ (d) $\sqrt{\dfrac{2gh}{v^2}+h^2}$

JEE Main-31.08.2021, Shift-I

Ans. (c) : Given that,

Speed of helicopter = v

Height of helicopter from ground = h



Component along x-axis

From 2nd equation of motion,

$$R = u_xT + \frac{1}{2}a_xT^2 \qquad (\because a_x = 0)$$

$$R = u_xT \qquad \text{.....(i)}$$

Component along y- axis

From 2nd equation of motion,

$$h = u_yT + \frac{1}{2}gT^2 \qquad (\because u_y = 0)$$

$$h = \frac{1}{2}gT^2$$

$$\frac{2h}{g} = T^2$$

$$T = \sqrt{\frac{2h}{g}} \qquad \text{.....(ii)}$$

Put the value of equation (ii) in equation (i)

$$R = u_x\sqrt{\frac{2h}{g}} \qquad (\because u_x = v)$$

$$R = v\sqrt{\frac{2h}{g}}$$

@apna_pdf

From figure,

Applying Pythagoras theorem,

$$BC^2 = h^2 + R^2$$

$$= h^2 + v^2\frac{2h}{g}$$

$$BC = \sqrt{h^2 + \frac{v^2 2h}{g}}$$

464. A bomb is dropped by fighter plane flying horizontally. To an observer sitting in the plane, the trajectory of the bomb is a

(a) hyperbola
(b) parabola in the direction of motion of plane
(c) straight line vertically down the plane
(d) parabola in a direction opposite to the motion of plane

JEE Main-26.08.2021, Shift-II

Ans. (c) : Relative velocity of bomb w.r.t. observer in plane = 0.

When the bomb is released from the plane, its horizontal component of the velocity will remain the same as the velocity of the plane. In vertical direction, the bomb will accelerate because of the acceleration due to gravity. Hence the bomb will move in a straight line vertically downwards with respect to the plane

465. Assertion (A): When the range of a projectile is maximum, the maximum height reached is 25% of its maximum range.

Reason (R): The maximum height of a projectile is proportional to the square of the velocity of projection.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)
(b) Both (A) and (R) are true and (R) is not the correct explanation of (A)
(c) (A) is true but (R) is false
(d) (A) is false but (R) is true

AP EAMCET-25.04.2018, Shift-II

Ans. (a) : As we know that,

$$R = \frac{u^2\sin 2\theta}{g}$$

For maximum range (θ = 45°)

$$R_{max} = 4H \qquad [R = 4H\cot\theta]$$

$$\frac{R}{4} = 25\% = H$$

R:

For maximum height (θ = 90°)

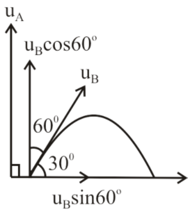
$$H_{max} = \frac{u^2}{2g} \qquad \Rightarrow H \propto u^2$$

466. Two balls are projected from same place simultaneously. One ball is projected vertically upwards and the other at an angle of 30° with the horizontal. If these two reach the ground at the same time then the ratio of their initial velocities is

(a) $\sqrt{2}:\sqrt{3}$ (b) $\sqrt{2}:1$
(c) $1:\sqrt{3}$ (d) 1 : 2

AP EAMCET-24.04.2019, Shift-II

Ans. (d) :



We know that,

$$\text{Time of flight} = \frac{2u_y}{g}$$

Where, u_y = Vertical components of projectile

$$T_A = \frac{2u_A}{g} \qquad \text{....(i)}$$

$$T_B = \frac{2u_B\cos 60^\circ}{g} \qquad \text{....(ii)}$$

From equation (i) and (ii)

$$T_A = T_B$$

$$\frac{2u_A}{g} = \frac{1}{2}\times\frac{2u_B}{g}$$

$$2u_A = u_B$$

$$\frac{u_A}{u_B} = \frac{1}{2} \quad \Rightarrow \quad 1:2$$

467. The Speed of a projectile at its maximum height is $\frac{\sqrt{3}}{2}$ times its initial speed. If the range of projectile is 'p' times the maximum height attained by it, then the value of 'p' is

(a) $2\sqrt{3}$ (b) $3\sqrt{2}$
(c) $\sqrt{3}$ (d) $4\sqrt{3}$

AP EAMCET-23.04.2019, Shift-II

Ans. (d) : Given,

$$U_H = \frac{\sqrt{3}}{2}u$$

$$R = pH$$

Let u be the initial and θ is the angle of the projection

We know that speed at the maximum height,

$$U_H = u\cos\theta$$

$$\frac{\sqrt{3}}{2}u = u\cos\theta$$

$$\cos\theta = \cos 30^\circ$$

$$\theta = 30^\circ$$

$$R = \frac{u^2\sin 2\theta}{g} \text{ and } H = \frac{u^2\sin^2\theta}{2g}$$

As, R = pH (Given)

$$\frac{u^2\sin 2\theta}{g} = p\frac{u^2\sin^2\theta}{2g}$$

@apna_pdf

$$2\sin\theta.\cos\theta = \frac{p}{2}\sin^2\theta$$

$$\tan\theta = \frac{4}{p}$$

So, $p = \dfrac{4}{\tan 30^o} \Rightarrow 4\sqrt{3}$

468. A ball is projected from ground into the air. At the height of 5 m, its velocity is $\vec{v} = \left(5\hat{i}+5\hat{j}\right)$ ms^{-1}. The maximum height reached by the ball is (Acceleration due to gravity = 10 ms^{-2})

(a) 8.75 m (b) 5.50 m
(c) 6.25 m (d) 10 m

AP EAMCET-07.07.2022, Shift-I

Ans. (c) : Given,

$h = 5cm,$ $\vec{v} = \left(5\hat{i}+5\hat{j}\right)m/s$

$g = 10m/s^2$ $v_x = 5m/s,\ v_y = 5m/s$

By equation of motion,

$$v_y^2 = u_y^2 - 2gh$$

$$u_y^2 = v_y^2 + 2gh$$

$$= 5^2 + 2 \times 10 \times 5$$

$$u_y^2 = 125$$

Maximum height, $H_{max} = \dfrac{u_y^2}{2g} = \dfrac{125}{2\times10} = 6.25m$

$H_{max} = 6.25m$

469. In a sports competition, a javelin is thrown at an angle 45º, which recorded a range of 90 m. The maximum height reached by the javelin is (Neglect air resistance and acceleration due to gravity = 10 ms^{-2})

(a) 45 m (b) 30 m
(c) 22.5 m (d) $30\sqrt{2}$ m

AP EAMCET-06.07.2022, Shift-I

Ans. (c) : Given,

Range = 90 m, $\theta = 45°$

Range of the Projectile $(R) = \dfrac{u^2\sin2\theta}{g}$

Range is maximum when $\sin2\theta = 1$, $\theta = 45°$

$$\therefore \quad R_{max} = \frac{u^2}{g}$$

$$90 = \frac{u^2}{10}$$

$$u = \sqrt{900}$$

$$u = 30m/s$$

Maximum height $(H) = \dfrac{u^2\sin^2\theta}{2g}$

$$H = \frac{(30)^2\left(\frac{1}{\sqrt{2}}\right)^2}{2\times10} = \frac{30\times30\times1}{4\times10}$$

$$H = 22.5m$$

470. The equation for the trajectory of a projectile is $y = \left(\dfrac{x}{\sqrt{3}} - \dfrac{x^2}{60}\right)$ m. The velocity of projection of the projectile is (Acceleration due to gravity = 10 ms^{-2})

(a) 8 ms^{-1} (b) 40 ms^{-1}
(c) 16 ms^{-1} (d) 20 ms^{-1}

AP EAMCET-06.07.2022, Shift-I

Ans. (d) : Given,

$$y = \left(\frac{x}{\sqrt{3}} - \frac{x^2}{60}\right)m \qquad ...(1)$$

The equation for the trajectory

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \qquad ...(2)$$

Compare equation (1) by (2)-

Where, y = Horizontal component

x = vertical component

g = Gravity value

u = Initial velocity

θ = angle of inclination of the initial from horizontal axis

$$x\tan\theta = \frac{x}{\sqrt{3}}$$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

$$\boxed{\theta = 30^0}$$

And $\dfrac{gx^2}{2u^2\cos^2\theta} = \dfrac{x^2}{60}$

$$\frac{1}{u^2} = \frac{2\cos^2\theta}{60g} = \frac{2\times\cos^2 30^0}{60\times10}$$

$$\frac{1}{u^2} = \frac{2\times\left(\frac{\sqrt{3}}{2}\right)^2}{60\times10} = \frac{2\times3}{4\times60\times10}$$

$$u^2 = \frac{4\times60\times10}{2\times3} = 2\times20\times10$$

$u^2 = 400 \Rightarrow u = 20$ m/s

471. In the projectile motion of an object, the object reaches its maximum height where its speed is half of initial speed. Then the ratio between range and maximum height of projectile is–

(a) $4\sqrt{3}$ (b) $\dfrac{\sqrt{3}}{4}$
(c) $\dfrac{4}{\sqrt{3}}$ (d) $\dfrac{2}{\sqrt{3}}$

AP EAMCET-08.07.2022, Shift-II

Ans. (c) : Given as,

$$U_H = \frac{1}{2}u$$

$$\frac{R}{H} = ?$$

@apna_pdf

Let u be the initial speed and θ is the angle of the projection

We know that speed at the maximum height ,

$$U_H = u\cos\theta$$

$$\frac{1}{2}u = u\cos\theta$$

$$\cos\theta = \cos 60^\circ$$

$$\theta = 60^\circ$$

So, $$R = \frac{u^2\sin 2\theta}{g} \text{ and } H = \frac{u^2\sin^2\theta}{2g}$$

$$\frac{R}{H} = \frac{u^2 2\sin\theta\cos\theta}{g} \times \frac{2g}{u^2\sin\theta\times\sin\theta}$$

$$\frac{R}{H} = \frac{4}{\tan\theta} \Rightarrow \frac{4}{\tan 60^\circ}$$

$$\frac{R}{H} = \frac{4}{\sqrt{3}}$$

$$\text{or } R : H = 4 : \sqrt{3}$$

472. A projectile with speed 50 ms^{-1} is thrown at an angle of 60° with the horizontal. The maximum height that can be reached is (acceleration due to gravity = 10 ms^{-2})

(a) 90.75 m (b) 70.00 m

(c) 85.00 m (d) 93.75 m

AP EAMCET-04.07.2022, Shift-I

Ans. (d) : Given data,

Speed (u) = 50 ms^{-1}

Angle (θ) = 60°

H_{max} = ?

We know that, maximum height of projectile motion

$$H_{max} = \frac{u^2\sin^2\theta}{2g}$$

$$H_{max} = \frac{50\times 50\left(\sin 60^\circ\right)^2}{2\times 10}$$

$$H_{max} = \frac{2500\times\left(\frac{\sqrt{3}}{2}\right)^2}{20} \Rightarrow H_{max} = \frac{2500\times 3}{4\times 20}$$

$$H_{max} = \frac{750}{8}$$

$$H_{max} = 93.75\text{m}$$

473. A projectile is fired with a velocity u at angle θ with the ground surface. During the motion at any time it is making an angle α with the ground surface. The speed of particle at this time will be

(a) $u\cos\theta\sec\alpha$ (b) $u\cos\theta.\tan\alpha$

(c) $u^2\cos^2\alpha\sin^2\alpha$ (d) $u\sin\theta.\sin\alpha$

JIPMER-2015

Ans. (a): Horizontal velocity at initial point,

$u_x = u\cos\theta$ [At projection angle = θ]

Horizontal velocity at final point,

$v_x = v\cos\alpha$ [At motion angle = α]

∵ Horizontal component of velocity is always same

$$u_x = v_x$$

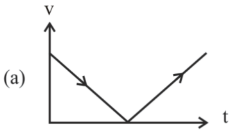
$$u\cos\theta = v\cos\alpha$$

$$v = \frac{u\cos\theta}{\cos\alpha}$$

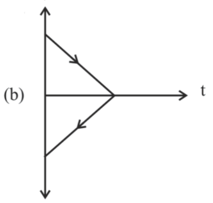
$$v = u\cos\theta.\sec\alpha$$

474. A ball is thrown vertically upwards. Which of the following graph represent v – t graph of the ball during its flight? (air resistance is neglected)

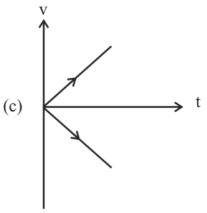
(a)



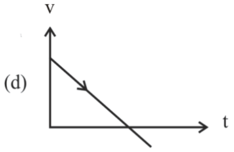
(b)



(c)

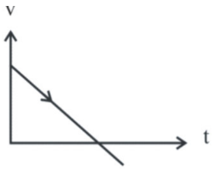


(d)



AP EAMCET-23.09.2020, Shift-II

Ans. (d) :



In the positive region the velocity decrease linearly, during rises and in the negative region velocity increase linearly during falls and the direction is opposite to each other during rise and fall, hence fall is shown in the negative region. Hence, the correct option is (d).

475. Range of a particle projected with an initial velocity u = 20 $\sqrt{2}$ m.s^{-1} at θ = 45° is

(a) 110 m (b) 25 m

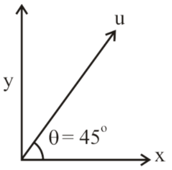
(c) 55 m (d) 80 m

AP EAMCET-25.09.2020, Shift-II

Ans. (d) : Given,

θ = 45°

$u = 20\sqrt{2}$ m/s



$$\text{Range (R)} = \frac{u^2\sin 2\theta}{g}$$

$$R = \frac{\left(20\sqrt{2}\right)^2\sin(2\times 45^\circ)}{10}$$

$$R = \frac{400\times 2\times\sin 90^\circ}{10}$$

$$R = \frac{400\times 2\times 1}{10} = 80\text{m}$$

@apna_pdf

476. For a projectile fired at an angle θ with the horizontal, the maximum height is:

(a) Directly proportional to θ
(b) Directly proportional to $\sin^2\theta$
(c) Directly proportional to $\sin\theta$
(d) Directly proportional to $\cos\theta$

AP EAMCET-25.09.2020, Shift-II

Ans. (b) : We know that,

Maximum height of projectile motion

$$H = \frac{u^2\sin^2\theta}{2g}$$

$$H \propto \sin^2\theta$$

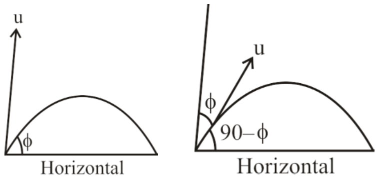
Hence, the maximum height is directly proportional to $\sin^2\theta$.

477. Two projectiles A and B are projected with the same initial speed. A is launched at an angle ϕ with the horizontal and B at an angle ϕ with the vertical. If A has a range R_1 and B has a range R_2, then

(a) $R_1 = 2R_2$
(b) $R_1 = 0.5R_2$
(c) $R_1 = R_2$
(d) $R_1 = 0.25R_2$

AP EAMCET-24.09.2020, Shift-I

Ans. (c):



We know that, Range of projectile motion is

$$R = \frac{u^2\sin 2\theta}{g}$$

Range for projectile A

$$R_A = \frac{u^2\sin 2\phi}{g} \quad .....(i)$$

Range for projectile B

$$R_B = \frac{u^2\sin 2(90^\circ - \phi)}{g}$$

$$R_B = \frac{u^2\sin(180^\circ - 2\phi)}{g}$$

$$R_B = \frac{u^2\sin 2\phi}{g} \quad ....(ii)$$

From equation (i) and (ii)

$R_A = R_B$

or $R_1 = R_2$

478. A projectile has a speed of 6 m. s^{-1} at its maximum height. If its total time of flight is 8 seconds the horizontal range is _____

(a) 12 m
(b) 24 m
(c) 36 m
(d) 48 m

AP EAMCET-24.09.2020, Shift-II

Ans. (d) : Given,

Horizontal velocity $(u_x) = u\cos\theta = 6$ m/s ....(i)

& Time of flight = 8 sec.

We know that,

$$\text{Time of flight}(T) = \frac{2u\sin\theta}{g}$$

$$\therefore \quad u\sin\theta = \frac{8\times 10}{2}$$

Vertical velocity $(u_y) = u\sin\theta = 40$ ....(ii)

$$\text{Horizontal range } R_x = \frac{u^2\sin 2\theta}{g}$$

$$R_x = \frac{2u^2\sin\theta\cos\theta}{g}$$

$$R_x = \frac{2\times(u\sin\theta)\times(u\cos\theta)}{g}$$

From equation (i) and (ii)

$$R_x = \frac{2\times 40\times 6}{10}$$

$$R_x = 48\text{m}$$

479. Three particles A, B and C projected from the same point with the same initial speeds making angles 30°, 45° and 60° respectively with the horizontal. Which of the following statement is correct?

(a) A, B and C have unequal ranges
(b) Ranges of A and C are equal and less than that of B.
(c) Ranges of A and C are equal and greater than that of B.
(d) A, B and C have equal range

AP EAMCET (Medical)-07.10.2020, Shift-I

Ans. (b) : Given, projection angle, 30°, 45° and 60° of three particles A, B and C.

As we know that,

$$\text{Range (R)} = \frac{u^2\sin 2\theta}{g}$$

For particle A, θ = 30°

$$R_{30^\circ} = \frac{u^2\sin 2\theta}{g}$$

$$R_{30^\circ} = \frac{u^2\sin(2\times 30^\circ)}{g}$$

$$R_{30^\circ} = \frac{u^2\sin 60^\circ}{g}$$

$$R_{30^\circ} = \frac{u^2\sqrt{3}}{2g}$$

For particle B, θ = 45°

$$R_{45^\circ} = \frac{u^2\sin(2\times 45^\circ)}{g} = \frac{u^2\sin 90^\circ}{g}$$

$$R_{45^\circ} = \frac{u^2}{g}$$

@apna_pdf

For particle C, θ = 60°

$$R_{60^\circ} = \frac{u^2 \sin 2\times60^\circ}{g} = \frac{u^2 \sin 120^\circ}{g}$$

$$R_{60^\circ} = \frac{u^2\sqrt{3}}{2g}$$

Hence, $R_{30^\circ} = R_{60^\circ}$, But R_{45° is not equal with then

$R_A = R_C < R_B$

480. The equation of motion of a projectile is $y = ax - bx^2$, where a, b are constants. Match the column- I with column-II

Column – I	Column-II
(i) The initial velocity of projection	(A) $\frac{a}{b}$
(ii) The horizontal range of projectile	(B) $a\sqrt{\frac{2}{bg}}$
(iii) The maximum height attained by projectile	(C) $\frac{a^2}{4b}$
(iv) The time of flight of projectile	(D) $\sqrt{\frac{g(l+a^2)}{2b}}$

option

	i	ii	iii	iv
(a)	A	B	C	D
(b)	D	A	B	C
(c)	D	A	C	B
(d)	A	D	C	B

AP EAMCET-25.04.2017, Shift-I

Ans. (c) :

(i) The initial velocity of Projection $= \sqrt{\frac{g(l+a)^2}{2b}}$

(ii) The horizontal range of projectile $= \frac{a}{b}$

(iii) The max. height attained by projectile $= \frac{a^2}{4b}$

(iv) The time of flight of projectile $= a\sqrt{\frac{2}{bg}}$

481. A body is projected at an angle θ so that its range is maximum. If T is the time of flight, then the value of maximum range is (acceleration due to gravity = g)

(a) $\frac{g^2T}{2}$ (b) $\frac{gT}{2}$

(c) $\frac{gT^2}{2}$ (d) $\frac{g^2T^2}{2}$

AP EAMCET -2014

Ans. (c) : We know that, range of projectile motion–

$$\text{Range } (R) = \frac{u^2 \sin 2\theta}{g}$$

For maximum range, θ = 45°

$$\therefore \quad R_{max} = \frac{u^2}{g} \qquad \text{....(i)}$$

$$\text{Time of flight } T = \frac{2u\sin\theta}{g} = \frac{2u\times\sin 45^\circ}{g}$$

$$T = \frac{2u}{\sqrt{2}.g} \Rightarrow T = \frac{\sqrt{2}u}{g}$$

$$u = \frac{gT}{\sqrt{2}}$$

Put $u = \frac{gT}{\sqrt{2}}$ in equation (i)

$$\text{Then, } R_{max} = \frac{g^2T^2}{2g}$$

$$R_{max} = \frac{gT^2}{2}$$

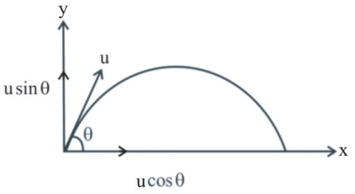
482. A body projected from the ground reaches a point X in its path after 3 seconds and from there it reaches the ground after further 6 seconds. The vertical distance of the point 'X' from the ground is (acceleration due to gravity = 10 ms^{-2})

(a) 30 m (b) 60 m

(c) 80 m (d) 90 m

AP EAMCET -2016

Ans. (d) :



Total flight Time (T) = 6 + 3 = 9 sec, g = 10ms^{-2}

As we know that, time of flight is,

$$T = \frac{2u\sin\theta}{g}$$

$$u\sin\theta = \frac{Tg}{2} = \frac{9\times10}{2}$$

$$u_y = u\sin\theta = 45 \text{ m/s}$$

$$s = ut + \frac{1}{2}at^2$$

∴ Vertical distance is,

$$h = u_yt + \frac{1}{2}gt^2 = 45\times3 - \frac{1}{2}\times10\,(3)^2$$

(∵ Vertical distance, g is negative)

h = 135 – 45 ⇒ h = 90 m

483. The range of a projectile is 100m. Its kinetic energy will be maximum after covering a distance of:

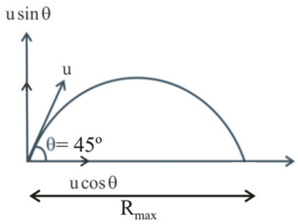
(a) 25m (b) 50m

(c) 75m (d) 100m

AP EAMCET-20.08.2021, Shift-I

@apna_pdf

Ans. (d) :



Given, Range of a projectile motion (R) = 100 m

$$\because \quad R = \frac{u^2 \sin 2\theta}{g}$$

For maximum Range, θ = 45°

$$R_{max} = \frac{u^2 \sin 2 \times 45^\circ}{g}$$

$$R_{max} = \frac{u^2 \sin 90^\circ}{g} = \frac{u^2}{g}$$

$$u^2 = R_{max} \cdot g$$

We know that,

$$\text{Kinetic energy (K.E.)} = \frac{1}{2} mu^2$$

$$\text{K.E.} = \frac{1}{2} m.R_{max}.g$$

$$\text{K.E.} \propto R_{max}$$

Hence, the kinetic energy will be maximum after the distance covered is the range (100 m).

484. When a ball is thrown with a velocity of 50 $m.s^{-1}$ at an angle 30^o with the horizontal, it remains in the air for .... second. (take = $10 m.s^{-2}$)

(a) 5
(b) 2.5
(c) 1.25
(d) 0.625

AP EAMCET-19.08.2021, Shift-I

Ans. (a) : Given,

Angle of projection (θ) = 30°
Initial velocity (u) = 50 m/s
$g = 10 \text{ m/s}^2$

$$\text{Time of flight (T)} = \frac{2u \sin\theta}{g}$$

$$T = \frac{2 \times 50 \times \sin 30^o}{10}$$

$$T = \frac{100 \times 1}{20}$$

$$\boxed{T = 5 \text{second}}$$

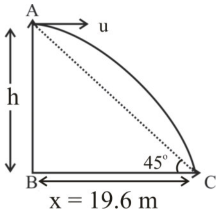
485. From the top of a tower 19.6 m high a ball is thrown horizontally. If the line joining the point of projection to the point where it hits the ground makes an angle of 45° with the horizontal, then the initial velocity of the ball is _____.

(a) 9.8 $m.s^{-1}$
(b) 4.9 $m.s^{-1}$
(c) 14.7 $m.s^{-1}$
(d) 2.8 $m.s^{-1}$

AP EAMCET-24.08.2021, Shift-I

Ans. (a) : Given,

h = 19.6 m, θ = 45°



In Δ ABC,

$$\tan\theta = \frac{AB}{BC}$$

$$\frac{h}{x} = \tan 45^o (\Delta ABC)$$

$$\frac{h}{x} = 1 \Rightarrow x = h$$

$$x = 19.6 \text{ m}$$

By equation of motion,

$$h = ut + \frac{1}{2} gt^2$$

$$h = \frac{1}{2} gt^2 \qquad \text{(For u = 0)}$$

$$\therefore \quad \text{Flight time } t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 19.6}{9.8}} = 2 \sec$$

Hence, initial velocity,

$$u = \frac{x}{t} = \frac{19.6}{2} = 9.8 \text{m/sec}$$

486. For a body projected vertically upwards with a velocity v_0 from the ground, match the following?

Column-I	Column-II
(A) $\overrightarrow{v_{av}}$ (Average velocity)	(i) $\frac{v_0}{g}$
(B) u_{av} (Average speed)	(ii) $\frac{\overrightarrow{v_1} + \overrightarrow{v_2}}{2}$ over any time-interval
(C) T_{ascent}	(iii) $\frac{v_0}{2}$ over the total time of its flight
(D) $T_{descent}$	(iv) $\frac{v_0}{g}$

	A	B	C	D
(a)	ii	iii	iv	i
(b)	iii	iv	i	ii
(c)	iv	i	ii	iii
(d)	iv	i	iii	ii

AP EAMCET-03.09.2021, Shift-I

@apna_pdf

Ans. (a) :

Column-I	**Column-II**
$\vec{v}_{av}$ (average velocity)	$\frac{\vec{v}_1+\vec{v}_2}{2}$ over any time-interval
u_{av} (average speed)	$\frac{v_0}{2}$ over the total time of its flight
T_{ascent}	$\frac{v_0}{g}$
$T_{descent}$	$\frac{v_0}{g}$

487. A particle of mass 'm' is projected with a velocity 'u' making an angle 'θ' with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height is ——

(a) 0 (b) $\frac{mu\sin^2\theta\cos\theta}{2g}$

(c) $\frac{2mu^2\cos^2\theta\sin\theta}{g}$ (d) $\frac{mu^3\sin^2\theta\cos\theta}{2g}$

AP EAMCET-19.08.2021, Shift-II

Ans. (d) : Velocity at maximum height , $v_x = u\cos\theta$

Maximum height, $H_{max} = \frac{u^2\sin^2\theta}{2g}$

Angular momentum about point of projection,

$$L = m(v_x \times H_{max})$$

$$L = \frac{m\times u\cos\theta\times u^2\sin^2\theta}{2g}$$

$$L = \frac{mu^3\sin^2\theta\cos\theta}{2g}$$

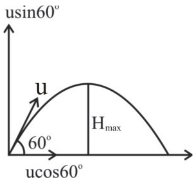
488. A projectile of mass 1 kg is projected with a speed of 10 m/s at an angle of 60° from the horizontal when projectile is at its highest point, its magnitude of angular momentum (about point of projection)

(a) $\frac{75}{2}$ Nm/s (b) $\frac{75}{4}$ Nm/s

(c) 75 Nm/s (d) 150 Nm/s

JIPMER-2019

Ans. (b) :



The magnitude of angular momentum of the projective about the origin at the highest point is

$$L = mrv = mH_{max}u\cos\theta$$

$$H = \frac{u^2\sin^2\theta}{2g}$$

$$L = \frac{mu^3\sin^2\theta\cos\theta}{2g} = \frac{1\times(10)^3\times\sin^2 60°\cos 60°}{2\times10}$$

$$= \frac{(1)\,(10)^3}{2\times10}\times\left(\frac{\sqrt{3}}{2}\right)^2\times\frac{1}{2} = \frac{75}{4}\text{ N- m/sec}$$

489. Two projectiles A and B are thrown from the same point with velocities ν and (0.5)ν respectively. If B was thrown at an angle 45° with the horizontal, find the angle with which A was projected, if it is known that both A and B have equal ranges?

(a) $\sin^{-1}\left(\frac{1}{4}\right)$ (b) $\frac{1}{2}\sin^{-1}\left(\frac{1}{4}\right)$

(c) $\frac{1}{2}\sin^{-1}\left(\frac{1}{8}\right)$ (d) $2\sin^{-1}\left(\frac{1}{4}\right)$

AP EAMCET-06.09.2021, Shift-II

Kerala CEE 2020

Ans. (b) : Given, $v_A = v$, $v_B = 0.5v$, $\theta_B = 45°$, $\theta_A = ?$

We know that

Range of Projective (R) $= \frac{v^2\sin 2\theta}{g}$

$R_A = \frac{v^2\sin 2\theta}{g}$ and $R_B = \frac{0.25v^2\sin 90°}{g}$

According to question Both range are equal,

$$R_A = R_B$$

$$\frac{v^2\sin 2\theta}{g} = \frac{0.25v^2\sin 90°}{g}$$

$$v^2\sin 2\theta = 0.25v^2$$

$$\sin 2\theta = 0.25$$

$$\sin 2\theta = \frac{1}{4}$$

$$2\theta = \sin^{-1}\left(\frac{1}{4}\right) \Rightarrow \theta = \frac{1}{2}\sin^{-1}\left(\frac{1}{4}\right)$$

490. A particle is projected at an angle of 30° from the horizontal with a speed of 10 m/s on the earth. It's time of flight, range, velocity of impact are respectively T, R, V. If this projectile is projected on the moon then its time of flight, range and velocity of impact is (assume gravitational field on moon is g/6 m/s²)

(a) 6T, 6R, 6V (b) 6T, 6R, V

(c) T, R, V (d) T, 6R, 6V

JIPMER-2019

Ans. (b) : On Earth,

Time of flight (T) $= \frac{2u\sin\theta}{g}$

Range of flight (R) $= \frac{u^2\sin 2\theta}{g}$

In moon,

@apna_pdf

$$\text{Time of flight, } (T') = \frac{2u\sin\theta}{g/6} = 6T$$

$$\text{Range of flight } (R') = \frac{u^2\sin 2\theta}{g/6} = 6R$$

The impact velocity is the velocity of an object when it hits ground or another object.

Velocity of impact on earth = Velocity of impact on moon

$$v = v'$$

491. If three objects are thrown with velocity $\sqrt{\frac{2gH}{3}}, \sqrt{2gH}, \sqrt{\frac{gH}{3}}$, then find the ratio of their maximum heights

(a) 2 : 6 : 1 (b) 2 : 5 :3

(c) 2 : 4 : 7 (d) 3 : 7 : 4

JIPMER-2019

Ans. (a) :

$$\text{So, } H_{max} = \frac{u^2\sin 2\theta}{2g}$$

$$H_{max} \propto u^2$$

$H_1 : H_2 : H_3 = u_1^2 : u_2^2 : u_3^2$

Put the values of u_1, u_2 and u_3

$H_1 : H_2 : H_3$

$= \frac{2gH}{3} : 2gH : \frac{gH}{3} = 2 : 6 : 1$

492. What is the range of a projection thrown with velocity 98 m/s with angle 30° from horizontal?

(a) $490\sqrt{3}$ m (b) $245\sqrt{3}$ m

(c) $980\sqrt{3}$ m (d) 100 m

JIPMER-2018

Ans. (a) :

$$\text{Range } (R) = \frac{u^2\sin 2\theta}{g}$$

$$R = \frac{98\times 98\times \sin 60^o}{9.8}$$

$$R = \frac{10\times 98\times\sqrt{3}}{2}$$

$$R = 5\times 98\sqrt{3}$$

$$\boxed{R = 490\sqrt{3}\,m}$$

493. The ratio of minimum kinetic energies of two projectiles of same mass is 4:1 and the ratio of maximum height attained by them is 4 : 1. Then the ratio of their ranges is______

(a) 2 : 1 (b) 8 : 1

(c) 16 : 1 (d) 4 : 1

AP EAMCET-25.04.2017, Shift-I

Ans. (d) : Given

$m_1 = m_2 = m$

$$\frac{K.E_1}{K.E_2} = \frac{4}{1}, \qquad \frac{H_1}{H_2} = \frac{4}{1}$$

$$\frac{K.E_1}{K.E_2} = \frac{4}{1}$$

$$\frac{\frac{1}{2}mu_1^2}{\frac{1}{2}mu_2^2} = \frac{4}{1}, \quad u_1 = 2u_2$$

$$\text{Max Height } (H) = \frac{u^2\sin^2\theta}{2g}$$

$$\because \quad \frac{H_1}{H_2} = \frac{4}{1}$$

$$\frac{u_1^2\sin^2\theta_1}{u_2^2\sin^2\theta_2} = \frac{4}{1}$$

$$\frac{4u_2^2\sin^2\theta_1}{u_2^2\sin^2\theta_2} = \frac{4}{1}$$

$\sin\theta_1 = \sin\theta_2$

$$\boxed{\theta_1 = \theta_2}$$

Hence,

$$\frac{R_1}{R_2} = \frac{u_1^2\sin 2\theta_1}{u_2^2\sin 2\theta_2}$$

$$\frac{R_1}{R_2} = \frac{4u_2^2\sin 2\theta_1}{u_2^2\sin 2\theta_2} \qquad [\because \theta_1 = \theta_2]$$

$$\frac{R_1}{R_2} = \frac{4}{1}$$

$$\boxed{R_1 : R_2 = 4 : 1}$$

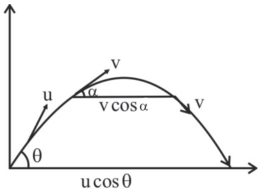
494. A projectile is thrown with a velocity of $10\sqrt{2}$ms^{-1} at an angle of 45° with the horizontal. The time interval between the moments when the speeds are $\sqrt{125}$ms^{-1} is (g = 10 ms^{-2})

(a) 0.5 s (b) 1.5 s

(c) 2 s (d) 1.0 s

AP EAMCET-25.04.2017, Shift-II

Ans. (d) :



Given,

$u = 10\sqrt{2}\,ms^{-1}$

$\theta = 45^o$

$v = \sqrt{125}\,m/s$

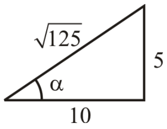
$$T = \frac{2v\sin\alpha}{g}$$

$v\cos\alpha = u\cos\theta = u\cos 45^o$

$$\sqrt{125}\cos\alpha = 10\sqrt{2}\times\frac{1}{\sqrt{2}}$$

@apna_pdf

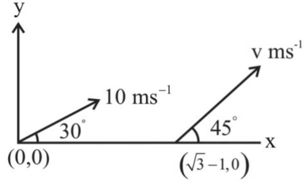
$$\boxed{\cos\alpha = \frac{10}{\sqrt{125}}}$$



$$\sin\alpha = \frac{5}{\sqrt{125}}$$

$$T = \frac{2u\sin\alpha}{g}, \quad T = \frac{2\times\sqrt{125}}{10}\times\frac{5}{\sqrt{125}} = 1\text{sec.}$$

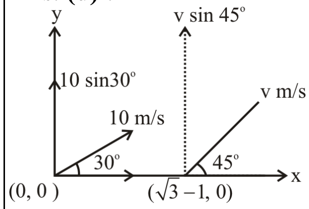
495. Two bodies are projected from points (0,0) and $\left(\sqrt{3}-1, 0\right)$ with velocities 10 ms^{-1} and v ms^{-1} respectively, as shown in the figure. The time after which they collide in space is _______



(a) 0.8 s
(b) 0.6 s
(c) 0.4 s
(d) 0.2 s

AP EAMCET-26.04.2017, Shift-II

Ans. (d) :



Given,

For particle – I

$u = 10$ m/s

$$u_x = 10\cos 30^\circ = 10\times\frac{\sqrt{3}}{2} = 5\sqrt{3} \text{ m/s}$$

$$u_y = 10\sin 30^\circ = 10\times\frac{1}{2} = 5 \text{ m/s}$$

For particle –II

$u' = v$

$$u'_y = v\cos 45^\circ = \frac{v}{\sqrt{2}}, \quad u'_x = v\sin 45^\circ = \frac{v}{\sqrt{2}}$$

In particles collide, (x, y) co-ordinates at time 't' for both particle is equal.

y – co-ordinates,

$$y_1 = u_y t - \frac{1}{2}gt^2$$

$$y_2 = u_y t - \frac{1}{2}gt^2$$

$$y_1 = y_2 \Rightarrow u_y t - \frac{1}{2}gt^2 = u'_y t - \frac{1}{2}gt^2$$

$$u_y = u'_y$$

$$5 \text{ m/s} = \frac{v}{\sqrt{2}} \Rightarrow v = 5\sqrt{2} \text{ m/s}$$

x – co-ordinates,

$$x_1 = u_x t, \; x_2 = u'_x t + \sqrt{3} - 1$$

$$x_1 = x_2, \; u_x t = u_x' t + \sqrt{3} - 1$$

$$5\sqrt{3}\,t = \frac{v}{\sqrt{2}}t + \sqrt{3} - 1 = \frac{5\sqrt{2}\,t}{\sqrt{2}} + \sqrt{3} - 1$$

$$t\left(5\sqrt{3} - 5\right) = \sqrt{3} - 1$$

$$t = \frac{\sqrt{3}-1}{5\sqrt{3}-5} = \frac{\sqrt{3}-1}{5(\sqrt{3}-1)} = \frac{1}{5} = 0.2\text{sec}$$

496. A body is projected into vertical X-Y plane with X-axis along horizontal and Y-axis along vertical with an initial velocity $\left(10\hat{i} + p\hat{j}\right)$.If the maximum height reached by the body is 50% of its range, then the value of p is

(a) 20 (b) 10 (c) 5 (d) 2

AP EAMCET-26.04.2017, Shift-II

Ans. (a) : Given that,

$$\text{Initial velocity} = (10\hat{i} + p\hat{j})$$

$$\tan\theta = \frac{p}{10}$$

$$H_{max} = \frac{1}{2}R,$$

$$\frac{u^2\sin^2\theta}{2g} = \frac{1}{2}\frac{u^2\sin 2\theta}{g}$$

$$\sin^2\theta = \sin 2\theta$$

$$\sin^2\theta = 2\sin\theta\cos\theta$$

$$\tan\theta = 2$$

$$\frac{p}{10} = 2$$

$$\boxed{p = 20}$$

497. A projectile is thrown from the surface of ground on Earth with velocity 16 m/s at an angle of 75° from the vertical. The projectile would be able to cover, approximately a horizontal distance (in meters)

(a) 13 (b) 17 (c) 15 (d) 21

AMU-2007

Ans. (a) : Given that,

$u = 16$ m/s

$\phi = 75^\circ, \theta = 90 - \phi = 90 - 75 = 15^\circ$

$$R = \frac{u^2\sin 2\theta}{g}$$

$$R = \frac{16\times16\times\sin(2\times15)}{10}$$

$$R = \frac{256\times\sin(30)}{10}$$

$$R = \frac{256\times1/2}{10} = \frac{128}{10} = 12.8 \approx 13\text{m}$$

@apna_pdf

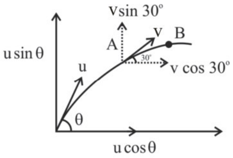
498. Two seconds after projection, a projectile is moving at 30º above the horizontal, after one more second it is moving horizontally. The initial speed of the projectile is (g = 10 ms^{-2})

(a) 10 m s^{-1} (b) $10\sqrt{3}$ m s^{-1}

(c) 20 m s^{-1} (d) $20\sqrt{3}$ m s^{-1}

AMU-2018

Ans. (d) :



As given that that after 3s of projection the projectile is moving horizontal.

So,

$$t = \frac{u\sin\theta}{g} = 3$$

u sinθ = 3g = 3 × 10 = 30 ....(i)

Horizontal component of velocity always remains same, so-

$$u\cos\theta = v\cos30^o$$

$$u\cos\theta = \frac{v\times\sqrt{3}}{2} = \frac{\sqrt{3}}{2}v$$

For vertical motion of projectile from point 0 to A.

$$v\sin30^o = u\sin\theta - gt$$

$$\frac{v}{2} = 30 - 10\times2$$

v = 20 m/s

$\because$ $u\cos\theta = v\cos30^o$

$$u\cos\theta = 20\times\frac{\sqrt{3}}{2} = 10\sqrt{3} \qquad ....(ii)$$

From equation (i) and (ii), we get

$$\frac{u\sin\theta}{u\cos\theta} = \frac{30}{10\sqrt{3}}$$

$$\tan\theta = \sqrt{3} \Rightarrow \theta = 60^o$$

From equation (ii),

$$u\cos\theta = 10\sqrt{3}$$

$$u\times\cos60^o = 10\sqrt{3}$$

$$u\times\frac{1}{2} = 10\sqrt{3}$$

$$u = 20\sqrt{3}\ m/s$$

499. The expression of the trajectory of a projectile is given as

$y = px - qx^2$

Where y and x are respectively the vertical and horizontal displacements, and p and q are constants. The time of flight of the projectile is

(a) $\frac{p^2}{4q}$ (b) $\frac{p^2}{2q}$

(c) $\sqrt{\frac{2p}{qg}}$ (d) $p\sqrt{\frac{2}{qg}}$

AMU-2016

Ans. (d) : $y = px - qx^2$ ....(i)

$$\frac{dy}{dx} = 0 \qquad [\text{max.height}]$$

$$p - 2qx = 0$$

$$\boxed{x = \frac{p}{2q}}$$

Putting value of x in equation (i),

$$y_{max} = H = p\cdot\frac{p}{2q} - q\left(\frac{p}{2q}\right)^2$$

$$H = \frac{p^2}{4q} \qquad ....(ii)$$

$$H = \frac{p^2}{4q} = \frac{u^2\sin^2\theta}{2g}$$

$$u\sin\theta = \sqrt{\frac{p^2g}{2q}}$$

$$T = \frac{2u\sin\theta}{g} \qquad ....(ii)$$

Putting value of u sinθ in equation (iii)

$$T = \frac{2}{g}\sqrt{\frac{p^2g}{2q}}, \qquad T = \sqrt{\frac{2p^2}{qg}} = p\sqrt{\frac{2}{qg}}$$

500. A projectile is thrown with an initial velocity of $\vec{V} = (p\hat{i} + a\hat{j})$m/s. If the range of the projectile is double the maximum height reached by it, then

(a) a = 2q (b) a = 4p

(c) a = 2p (d) a = p

AMU-2011

Ans. (c) : Given,

$$\vec{V} = (p\hat{i} + a\hat{j})$$

let angle of projection = θ

$$\tan\theta = \frac{V_y}{V_X}$$

$$\tan\theta = \left(\frac{a}{p}\right) \qquad ....(i)$$

given that R = 2H

$$\frac{u^2\sin2\theta}{g} = \frac{u^2\sin^2\theta}{2g}\times2$$

$$\frac{2u^2\sin\theta\cos\theta}{g} = \frac{u^2\sin^2\theta}{2g}\times2$$

$$\frac{\cos\theta}{\sin\theta} = \frac{1}{2}$$

$$\cot\theta = \frac{1}{2}$$

$$\tan\theta = 2 \qquad .....(ii)$$

From equation (i) and (ii), we get-

$$\frac{a}{p} = 2$$

$$a = 2p$$

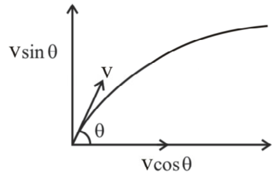
@apna_pdf

501. A ball of mass m is projected upward with a speed v_0. The speed at a height h is (Neglecting air resistance)

(a) independent of angle and direction of projection
(b) independent of mass, angle and the direction of projection
(c) dependent on the direction of projection
(d) dependent on the shape, size and mass of the ball and angle of projection
(e) dependent on mass of the ball but independent of the angle and direction of projection

Kerala CEE-2019

Ans. (c) :



If a ball of mass m and speed v_o is thrown upward, then speed at height h is-

$$v^2 = u^2 - 2gh$$

$$v^2 = v_0^2 \sin^2\theta - 2gh$$

So, the speed depend on the direction of projection.

502. An object of mass 2 m is projected with a speed of 100 ms^{-1} at an angle $\theta = \sin^{-1}\left(\frac{3}{5}\right)$ to the horizontal. At the highest point, the object breaks into two pieces of same mass m and the first one comes to rest. The distance between the point of projection and the point of landing of the bigger piece (in metre) is (Given, $g = 10\ ms^{-2}$)

(a) 3840 (b) 1280
(c) 1440 (d) 960

EAMCET-2007

Ans. (c): Horizontal range of the abject fired,

$$R = \frac{u^2 \sin 2\theta}{g}$$

At the highest point, when object is exploded into two equal masses and one comes to rest, then

by law of conservation of momentum

$$2mu\cos\theta = m(0) + mv$$

or $\quad v = 2u\cos\theta$

It means, the horizontal velocity becomes double at the highest point, hence it will cover double the distance during the remaining flight.

∴ Total horizontal range of the other part

$$R' = \frac{R}{2} + R = \frac{3R}{2}$$

$$= \frac{3}{2}\frac{u^2 \sin 2\theta}{g} = \frac{3}{2} \times \frac{(100)^2 \times 2\sin\theta\cos\theta}{g}$$

$$= \frac{3}{2} \times \frac{(100)^2 \times 2 \times \frac{3}{5} \times \frac{4}{5}}{10} \quad \left(\begin{matrix} \text{If } \sin\theta = \frac{3}{5} \\ \cos\theta = \frac{4}{5} \end{matrix}\right)$$

$$= 1440\ \text{m}$$

503. A ball is thrown vertically upward from the ground with a speed of 25.2 m/s. The ball will reach the highest point of its journey in

(a) 5.14 s (b) 3.57 s
(c) 2.57 s (d) 1.29 s

NDA (II) 2016

Ans. (c) : u = 25.2 m/s

for vertical upward direction.

$$H = \frac{u^2}{2g} = \frac{25.2 \times 25.2}{2 \times 9.8} = 32.4\,\text{m}$$

and $\quad t = \frac{u}{g} = \frac{25.2}{9.8}$

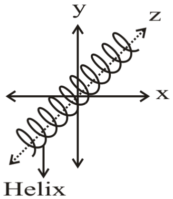
$$\boxed{t = 2.57\text{s}}$$

504. Consider the motion of a particle described by x = a cos t, y = a sin t and z = t. The trajectory traced by the particle as a function of time is

(a) Helix (b) Circular
(c) Elliptical (d) Straight line

TS EAMCET (Engg.)-2017

Ans. (a) : Given, x = a cost, y = a sin t, z = t



$$x^2 + y^2 = a^2\cos^2 t + a^2 \sin^2 t$$

$$= a^2(\cos^2 t + \sin^2 t)$$

$x^2 + y^2 = a^2$ is a circular equation

Then,

In one revaluation the particle move a distance of 1 unit along z-axis,

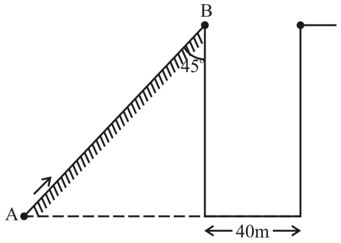
$$z = t$$

$$\frac{dz}{dt} = 1$$

Hence, the trajectory traced by the particle as a function of time is helix.

505. A body is projected up a smooth inclined plane of length $20\sqrt{2}$ m from point A as shown in the figure. The top B of the inclined plane is connected to a well of diameter 40 m. If the body just manages to cross the well then the velocity of projection is (Acceleration due to gravity, $g = 10\ ms^{-2}$)

@apna_pdf

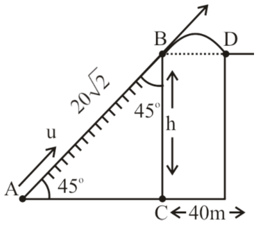


(a) $40\ ms^{-1}$ (b) $40\sqrt{2}\ ms^{-1}$

(c) $20\ ms^{-1}$ (d) $20\sqrt{2}\ ms^{-1}$

AP EAMCET (22.04.2019) Shift-II

Ans. (d): According the question,



In ΔABC,

$$\frac{h}{20\sqrt{2}} = \cos 45^\circ$$

$$h = 20\sqrt{2}\left(\frac{1}{\sqrt{2}}\right)$$

$$h = 20\text{ m}$$

From third equation of the motion,

$$v^2 = u^2 + 2gh$$

$$v = \sqrt{2gh} \qquad (\because u = 0)$$

$$v = \sqrt{2\times10\times20} = 20\text{ m/s}$$

Net energy at a point B,

$$\frac{1}{2}mv^2 + mgh = \frac{1}{2}m(20)^2 + m\times10\times20$$

$$= m(200 + 200) = 400\text{ m}$$

Net energy at point D to cross the well,

$$E_D = \frac{1}{2}mv_D^2$$

So, $\frac{1}{2}mv_D^2 = 400\text{ m}$

$$v_D = 20\sqrt{2}\ ms^{-1}$$

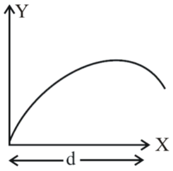
506. A particle is projected with velocity v_0 along X-axis. The deceleration on the particle is proportional to the square of the distance from the origin i.e, $a = \alpha x^2$ the distance at which the particle stops is

(a) $\sqrt{\frac{3v_0}{2\alpha}}$ (b) $\left(\frac{3v_0}{2\alpha}\right)^{\frac{1}{3}}$

(c) $\sqrt{\frac{2v_0^2}{3\alpha}}$ (d) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$

CG PET- 2008

Ans. (d) :



If particle is projected with velocity v_0 from origin in X–direction

So, initial velocity = v_0, final velocity = 0

Deceleration $a = -\alpha x^2$

Let distance covered by the particle be d.

$$a = -\alpha x^2$$

Or $\frac{dv}{dt} = -\alpha x^2$

$$\left[\because\ v = \frac{dx}{dt} \Rightarrow dt = \frac{dx}{v}\right]$$

Now, $\frac{dv}{dx/v} = -\alpha x^2$

$$\frac{vdv}{dx} = -\alpha x^2$$

$$vdv = -\alpha x^2 dx$$

Now, integrating with limit v_0 to 0 and from 0 to d.

$$\int_{v_0}^{0} vdv = \int_0^d \left(-\alpha x^2\right)dx$$

$$\left[\frac{v^2}{2}\right]_{v_0}^{0} = -\alpha\left[\frac{x^3}{3}\right]_0^d$$

$$0 - \frac{v_0^2}{2} = -\alpha\left[\frac{d^3}{3} - 0\right]$$

$$\frac{v_0^2}{2} = \frac{\alpha d^3}{3}$$

$$d^3 = \frac{3v_0^2}{2\alpha}$$

$$d = \left[\frac{3v_0^2}{2\alpha}\right]^{1/3}$$

507. A body is projected vertically upwards with a velocity of 10 ms^{-1} and another body is projected simultaneously from the same point with a velocity of 20 ms^{-1} at an angle of $\frac{\pi}{6}$ with the horizontal. The distance between the two bodies after one second from the time of projection is (Acceleration due to gravity is 10 ms^{-2})

(a) 10 m (b) $10\sqrt{3}$m

(c) 20 m (d) $20\sqrt{3}$m

AP EAMCET(Medical)-2016

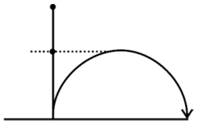
@apna_pdf

Ans. (b) : Given that,

Projectile velocity of body A, $v_A = 10$ m/sec

Projectile velocity of body B, $v_B = 20$ m/sec

$$\text{Angle, } \theta = \frac{\pi}{6} = 30^o$$



Vertical velocity of A = 10 sin 90°

$$v_{A_Y} = 10 \text{ m/sec}$$

Horizontal velocity

$$v_{A_x} = v_A \cos 90^o$$

$$= 10 \times 0$$

$$v_{A_x} = 0$$

Distance = d_1

Vertical velocity of body B, $v_{B_y} = 20 \sin 30^o$

$$= 10 \text{ m/sec.}$$

height of both projectile body is same .

Horizontal velocity of body B, $v_{B_x} = v_B \cos\theta$

$$= 20 \cos 30^o$$

$$= 20\frac{\sqrt{3}}{2}$$

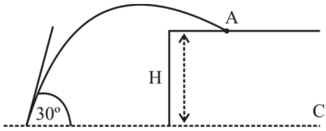
$$v_{B_x} = 10\sqrt{3} \text{ m/sec}$$

Distance = d_2

Total distance, $d = d_1 + d_2 = 0 + 10\sqrt{3} = 10\sqrt{3}$

508. A ball is projected at a cliff of height H with an initial speed of 100 m/s at an angle 30° above the horizontal. The ball hits the point A on the cliff after 5s. The height of the cliff is:

(Assume $g = 10$ m/s^2)

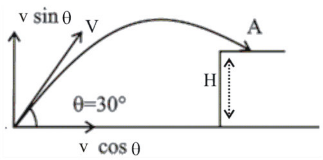


(a) 50 m (b) 100 m

(c) 125 m (d) 150 m

TS EAMCET 29.09.2020, Shift-II

Ans. (c) :



To get the height of the cliff, use the equation of velocity–

$$s = ut - \frac{1}{2}gt^2 \quad \_\_\_\_(i)$$

$$\because \quad u = v\sin\theta \quad \_\_\_\_\_\_\_\_\_\_(ii)$$

Given, u = 100 m/s. θ=30°

t = 5 sec, $g = 10$ m/s^2

From eq. (ii), $u = v \sin\theta$

$$u = v \times \sin 30^o$$

$$u = 100 \times \frac{1}{2} = 50\text{m/s}$$

For height of the cliff,

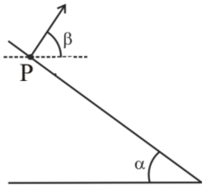
$$s = H$$

From eq. (i), $H = ut - \frac{1}{2}gt^2$

$$H = v\sin\theta \times t - \frac{1}{2}g\cdot t^2$$

$$= 50 \times 5 - \frac{1}{2} \times 10 \times 5^2 = 125 \text{ m}$$

509. Particle A is released from a point P on a smooth inclined plane. Which makes an angle α with the horizontal. Simultaneously from P another particle B is projected in the same direction, with an initial velocity u at an angle β with the horizontal. If both A and B meet again on the inclined plane. α and β are related as______

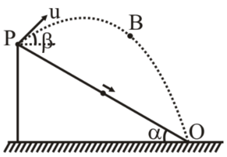


(a) $\alpha + \beta = \frac{\pi}{4}$ (b) $\alpha + \beta = \frac{\pi}{6}$

(c) $\alpha + \beta = \frac{\pi}{2}$ (d) $\alpha + \beta = \frac{\pi}{3}$

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (c) :



Consider motion of B along the plane,

Initial velocity = u cos (α + β) and acceleration = g sin α

Using second equation of motion along the inclined plane, (for particle B)

$$\therefore \quad OP = u\cos(\alpha+\beta) \times t + \frac{1}{2}g\sin\alpha t^2 \text{.....(1)}$$

For motion of particle A along the plane,

Initial velocity = 0

Acceleration = g sin α

Using second equation of motion along the inclined plane, (for particle A)

$$\therefore \quad OP = \frac{1}{2}g\sin\alpha t^2 \text{ ....(2)}$$

From Equation (1) and (2), we get

@apna_pdf

ut cos (α + β) = 0

so, either t = 0 or $\alpha+\beta=\dfrac{\pi}{2}$

Thus, the condition for the particles to collide is

$$\alpha+\beta=\frac{\pi}{2}$$

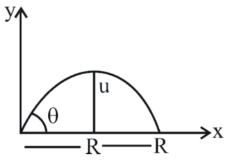
510. A ball is thrown at a speed of 20 m/s at an angle of 30° with the horizontal. The maximum height reached by the ball is (use g = 10m/s²)

(a) 2 m (b) 3 m

(c) 4 m (d) 5 m

TS EAMCET (Engg.)-2017

Ans. (d) : Given data,



Initial speed, u = 20 m/s

θ = 30°

According the formula

The maximum height, $H_{max}=\dfrac{u^2\sin^2\theta}{2g}$

$$H_{max}=\frac{20\times20(\sin30^\circ)^2}{2\times10} \qquad [\therefore\ g=10\text{m/s}^2]$$

$$H_{max}=\frac{20\times20\times\frac{1}{2}\times\frac{1}{2}}{20}$$

H_{max} = 5m

511. A bullet is fired at time t = 0 with velocity 20 m/s and at an initial angle of 30° with the horizontal. The tan angle between the displacement vector and the horizontal after time 0.1 s is. (Assume g = 10 m/s²)

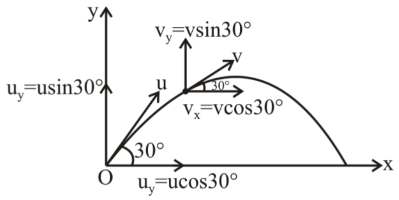
(a) $\dfrac{38}{20\sqrt{3}}$ (b) $\dfrac{19}{20\sqrt{3}}$

(c) $\dfrac{19}{20}$ (d) $\dfrac{19\sqrt{3}}{20}$

TS EAMCET 19.07.2022, Shift-II

Ans. (b) : : Initially bullet was at the origin.

We have to find out x and y co-ordinate of the bullet after 0.1 sec.



As we know horizontal component of velocity will not change, $u_x = v_x$

$x = u_x \times t = u\cos30^\circ \times t$

$$x=20\times\frac{\sqrt{3}}{2}\times0.1=\sqrt{3}$$

$$y=u_yt+\frac{1}{2}a_yt^2$$

$$y=u\sin30\times t-\frac{1}{2}gt^2 \qquad (\because a_y=-g)$$

$$y=20\times\frac{1}{2}\times0.1-\frac{1}{2}\times10\times0.1^2$$

$$y=1-\frac{1}{20}=\frac{19}{20}$$

Assume the angle between the displacement vector and the horizontal after time 0.1 sec is θ

$$\tan\theta=\frac{y}{x}=\frac{19}{20}\times\frac{1}{\sqrt{3}}$$

$$\tan\theta=\frac{19}{20\sqrt{3}}$$

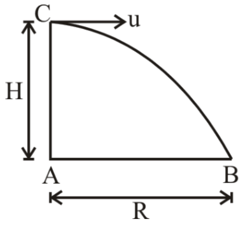
512. A body is thrown horizontally from the top of a tower of 5 m height. It touches the ground at a distance of 10 m from the foot of the tower. The initial velocity of the body is

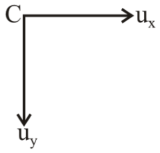
(a) 2.5 ms^{-1} (b) 5 ms^{-1}

(c) 10 ms^{-1} (d) 20 ms^{-1}

EAMCET-2000

Ans. (c) :





Given, Height (H) = 5 m, Range (R) = 10 m

For vertical direction,

$u_y = 0$, a = g m/s², H = 5 m

$$H=u_yt+\frac{1}{2}at^2$$

$$H=0+\frac{1}{2}\times g\times t^2$$

$$t=\sqrt{\frac{2H}{g}}=\sqrt{\frac{2\times5}{10}} \qquad (\because g=10\text{ m/s}^2)$$

t = 1 sec

For horizontal direction,

u_x = u, R = 10 m, a = 0, t = 1 sec

$$R=u_xt+\frac{1}{2}at^2$$

$10 = u_xt + 0$

10 = u × 1

u = 10 m/s

@apna_pdf

(e) Circular Motion : Uniform Circular Motion, Dynamic Circular Motion

513. A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute. The magnitude of acceleration of stone is $\frac{1936}{x}$ ms^{-2}. The value of x_____ $\left(\text{Take, } \pi = \frac{22}{7}\right)$

JEE Main-30.01.2023, Shift-II

Ans. (125) : Given, R = 180 cm

No. of revolution = 28/min

We know that,

$$v = R\omega$$

$$v = \frac{180}{100} \times \left(\frac{2\pi \times 28}{60}\right) = \left(\frac{132}{25}\right) \text{m/s}$$

$$\therefore \quad a = \frac{v^2}{R} = \left(\frac{132}{25}\right)^2 \times \frac{100}{180} = \frac{1936}{125} \text{m/s}^2$$

According to the question,

$$a = \frac{1936}{x} \text{ms}^{-2}$$

∴ Value of x = 125

514. A car is moving with a constant speed of 20 m/s in a circular horizontal track of radius 40m. A bob is suspended from the roof of the car by a massless string. The angle made by string with the vertical will be ; (Take g = 10 m/s^2)

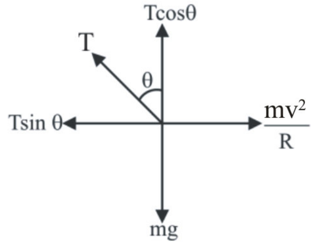
(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{2}$

(c) $\frac{\pi}{4}$ (d) $\frac{\pi}{3}$

JEE Main-25.01.2023, Shift-I

Ans. (c) : Given, Speed (v) = 20 m/sec

Radius (R) = 40 m



According to the free body diagram –

$$T\sin\theta = \frac{mv^2}{R} \quad \text{.....(i)}$$

$$T\cos\theta = mg \quad \text{.....(ii)}$$

Dividing equation (i) by equation (ii), we get–

$$\tan\theta = \frac{v^2}{Rg}$$

$$\theta = \tan^{-1}\left(\frac{v^2}{Rg}\right)$$

$$\theta = \tan^{-1}\left(\frac{(20)^2}{40 \times 10}\right) = \tan^{-1}(1)$$

$$\theta = \frac{\pi}{4}$$

515. A car is moving on a horizontal curved road with radius 50 m. The approximate maximum speed of car will be, if friction between tyres and road is 0.34 [take g = 10 ms^{-2}]

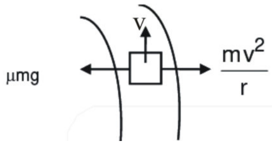
(a) 3.4 ms^{-1} (b) 13 ms^{-1}

(c) 14 ms^{-1} (d) 22.4 ms^{-1}

JEE Main-29.01.2023, Shift-I

Ans. (b) : Given, radius (r) = 50 m

Friction between tyres and road = 0.34



For maximum speed,

$$\mu mg = \frac{mv^2}{r}$$

$$v = \sqrt{\mu g r}$$

Putting these value, we get–

$$v = \sqrt{0.34 \times 10 \times 50}$$

$$v = 13 \text{ m/s}$$

516. If a particle tied to the end of string is set in circular motion then the tension of the string is

(a) always parallel to the velocity of the particle

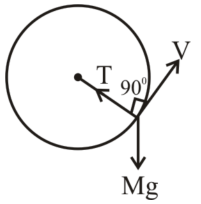
(b) always perpendicular to the velocity of the particle

(c) perpendicular to the velocity of the particle only at one instant

(d) parallel to the velocity of the particle only at one instant

EAMCET-1996

Ans. (b) : If a particle tied to the end of a string is set in circular motion then the tension of the string is always perpendicular to the velocity of the particle because the tension force act towards the center and velocity towards the tangent of the circle.



517. A stone tied to a string is rotated in a vertical circle. The minimum speed with which the string has to be rotated

(a) decreases with increasing mass of the stone

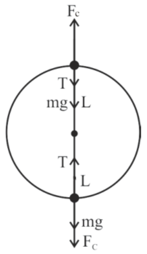
(b) is independent of the mass of the stone

@apna_pdf

(c) decreases with increasing in length of the string
(d) is independent of the length of the string

EAMCET-1998
EAMCET 21.09.2020 (shift-I)
UPCPMT - 2002
BC ECE - 2012

Ans. (b) : The stone is rotating in vertical circle of radius L.



So, At the highest point, tension of the string is zero.

$$mg = F_c$$

$$\therefore \quad mg = m\frac{v_{max}^2}{L}$$

$$v_{max}^2 = gL$$

Apply law of conservation of energy,

$$P_i + K.E_i = P_f + K.E_f$$

$$0 + \frac{1}{2}mv_{min}^2 = mg(L+L) + \frac{1}{2}mv_{max}^2$$

$$\frac{1}{2}mv_{min}^2 = 2mgL + \frac{1}{2}m.(Lg)$$

$$v_{min}^2 = 5gL$$

$$v_{min} = \sqrt{5gL}$$

So, we can say that minimum velocity at lowest point is free from mass of the stone.

518. A car is moving on a circular level road of curvature 300 m. If the coefficient of friction is 0.3 and acceleration due to gravity 10 ms^{-2}, the maximum speed that car can have is

(a) 30 kmh^{-1}
(b) 81 kmh^{-1}
(c) 108 kmh^{-1}
(d) 162 kmh^{-1}

EAMCET-1999

Ans. (c) : Given,
Curvature (r) = 300 m
Coefficient of friction (μ) = 0.3
Acceleration due to gravity (g) = 10 m / sec^2
For maximum speed of car,
Centripetal force = Frictional force

$$\frac{mv_{max}^2}{r} = \mu mg$$

$$v_{max}^2 = \mu rg$$

$$v_{max} = \sqrt{\mu rg}$$

$$v_{max} = \sqrt{0.3 \times 300 \times 10}$$

$$v_{max} = \sqrt{900}$$

$$v_{max} = 30 \text{ m/sec} = 30 \times \frac{18}{5} \text{ km/h}$$

$$v_{max} = 108 \text{ km/h}$$

519. A body is thrown vertically upwards with an initial velocity u reaches maximum height in 6 sec. The ratio of distance travelled by the body in the first and seventh second is

(a) 1 : 1
(b) 11 : 1
(c) 1 : 2
(d) 1 : 11

EAMCET-2000

Ans. (b) : Velocity becomes zero after 6 sec.
We know that,

$$v = u + at$$

$$0 = u + 6(-g)$$

$$0 = u - (10\times 6)$$

$$u = 60 \text{ m/sec}$$

Distance in nth second is given by,

$$s_n = u + \frac{a}{2}(2n-1)$$

For, $n = 1$

$$s_1 = 60 - \left(\frac{10}{2}\right)(1)$$

$$s_1 = 60 - 5 = 55\text{m}$$

For, $n = 7$

$$s_7 = 60 - \left(\frac{10}{2}\right) \times 13$$

$$s_7 = -5 \text{ m}$$

The negative sign indicates the body is moving in downward direction.

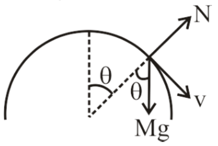
Ratio of the distance travelled between 1st and 7th Second $\frac{s_1}{s_2} = \frac{55}{5} = 11:1$

520. A body of mass M kg is on the top point of a smooth hemisphere of radius 5 m. It is released to slide down the surface of the hemisphere. It leaves the surface when velocity is 5 ms^{-1}. At this instant the angle made by the radius vector of the body with the vertical is (acceleration due to gravity = 10 ms^{-2})

(a) 30°
(b) 45°
(c) 60°
(d) 90°

EAMCET-2002

Ans. (c) : Given, mass = M kg, radius (R) = 5 m, velocity (v) = 5 m/sec, g = 10 m/sec^2



Body can leave surface of hemisphere if there is no reaction force i.e. N = 0

$$Mg\cos\theta = \frac{Mv^2}{R} \Rightarrow \cos\theta = \frac{v^2}{gR}$$

$$\cos\theta = \frac{5\times 5}{10\times 5} \Rightarrow \cos\theta = \frac{1}{2}$$

$$\theta = 60^\circ$$

@apna_pdf

521. A bucket filled with water is tied to a rope of length 0.5 m and is rotated in a circular path in vertical plane. The least velocity it should have at the lowest point of circle so that water does not spill is, ($g = 10\ ms^{-2}$)

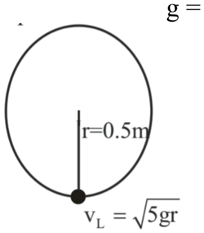
(a) $\sqrt{5}\ ms^{-1}$ (b) $\sqrt{10}\ ms^{-1}$

(c) $5\ ms^{-1}$ (d) $2\sqrt{5}\ ms^{-1}$

EAMCET-2007

Ans. (c) : Given, length of rope (r) = 0.5 m

$g = 10 m/sec^2$



We know,

Velocity at lowest point $(v_L) = \sqrt{5gr}$

$v_L = \sqrt{5\times10\times0.5} \Rightarrow v_L = \sqrt{25}$

$v_L = 5\ ms^{-1}$

522. A body is tied with a string and is given a circular motion with velocity v in radius r. The magnitude of the acceleration is

(a) v/r (b) v^2/r

(c) v/r^2 (d) v^2/r^2

DCE-2009

Ans. (b) : When a body is tied with a string and is given a circular motion with velocity v in radius r then the magnitude of acceleration is $\frac{v^2}{r}$.

523. A block of mass M at the end of the string is whirled round a vertical circle of radius R. The critical speed of the block at the top of the swing is

(a) $(R/g)^{1/2}$ (b) g/R

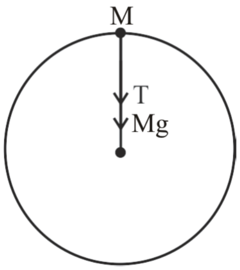
(c) M/Rg (d) $(Rg)^{1/2}$

DCE-2009

J & K CET - 1999

Manipur UGET - 2011

Ans. (d) :



The block is rotating in circular path of radius R.

So, at the highest point tension of the string is zero.

$$T + Mg = \frac{Mv^2}{R}$$

$$\therefore \quad 0 + Mg = \frac{Mv^2}{R}$$

$$v = \sqrt{gR}$$

$$v = (Rg)^{1/2}$$

524. A car is moving in a circular horizontal track of radius 10 m with a constant speed of $10 ms^{-1}$. A bob is suspended from the roof of the car by a light wire of length 1.0m. The angle made by the wire with the vertical is (in radian)

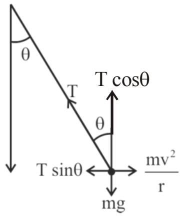
(a) 0 (b) $\frac{\pi}{3}$

(c) $\frac{\pi}{6}$ (d) $\frac{\pi}{4}$

Karnataka CET-2022

MHT CET-2020

Ans. (d) : Given, r = 10m, v = 10m/s, g = 10 m/s^2



$$T\sin\theta = \frac{mv^2}{r} \quad \ldots(i)$$

$$T\cos\theta = mg \quad \ldots..(ii)$$

Dividing equation (i) by equation (ii), we get –

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan\theta = \frac{10^2}{10\times10} = 1 \Rightarrow \theta = 45° = \frac{\pi}{4}$$

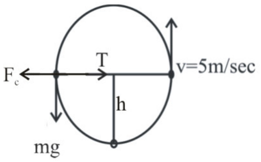
525. A ball of mass 0.6 kg attached to a light inextensible string rotates in a vertical circle of radius 0.75 m such that it has a speed of 5 ms^{-1} when the string is horizontal. Tension in string when it is horizontal on other side is ($g = 10\ ms^{-2}$)

(a) 30 N (b) 26 N

(c) 20 N (d) 6 N

AP EAMCET(Medical)-2007

Ans. (c) : Given, m = 0.6 kg, radius (r) = 0.75 m and speed (v) = 5 m/sec



By balancing the forces,

$$\text{Tension } F_c = \frac{mv^2}{r} = \frac{0.6\times5^2}{0.75} = 20N$$

@apna_pdf

526. A particle is moving in a circle of radius 'r' with a constant speed 'v'. The change in velocity after the particle has travelled a distance equal to $\left(\frac{1}{8}\right)$ of the circumference of the circle is:

(a) zero (b) 0.500 v
(c) 0.765 v (d) 0.125 v

AP EAMCET(Medical)-2006
JEE Main - 11.01.2019 Shift-I

Ans. (c) : Given, radius = r, velocity = v

Distance $=\left(\frac{1}{8}\right)$ of the circumference of the circle

Angle covered by the particle $=\left(\frac{1}{8}\right)\times 360° = 45^o$

Then, change in velocity $(\Delta v) = \sqrt{v_1^2 + v_2^2 - 2v_1.v_2\cos\theta}$

Here, $v_1 = v_2 = v$ and $\theta = 45°$

$$\Delta v = \sqrt{v^2 + v^2 - 2v^2\cos 45°}$$
$$= \sqrt{2v^2 - 2v^2 \times \frac{1}{\sqrt{2}}}$$
$$= v\sqrt{2-\sqrt{2}} = 0.765\text{ v}$$

527. Assertion (A): If a body moving in a circular path has constant speed, then there is no force acting on it.
Reason (R): The direction of the velocity vector of a body moving in a circular path is changing.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true and R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

AP EAMCET(Medical)-2004

Ans. (d) : Here assertion is wrong because a body moving in a circular path has a constant speed then there is a centripetal force acting on it. It has constant magnitude but changing direction.
Reason is correct, the direction of the velocity vector of a body moving in a circular path is changing that provide centripetal acceleration by Newton's second law of force.

$$F=ma=\frac{mv^2}{r} = mr\omega^2$$

528. A particle tied to a string of negligible weight and length *l* is swinging in a horizontal circular path with constant angular velocity having time period T. If the string length is shortened by $\frac{l}{2}$, while the particle is in motion, the period is:

(a) 4T (b) 2T
(c) T (d) $\frac{T}{4}$

AP EAMCET(Medical)-2000

Ans. (d) : Given, r_1=string length (l), time period = T
r_2 = Shortened length of string ($l/2$)
Here, angular momentum about centre will be conserved in circular motion.
Then, according to the law of conservation of angular momentum-

$$mv_1r_1 = mv_2r_2$$
$$m\omega_1 r_1^2 = m\omega_2 r_2^2 \qquad [\because v = r\omega]$$
$$\frac{\omega_1}{\omega_2} = \left(\frac{r_2}{r_1}\right)^2$$
$$\frac{\omega_1}{\omega_2} = \left(\frac{l}{2l}\right)^2$$
$$\frac{\omega_1}{\omega_2} = \frac{1}{4} \text{ .... (i)}$$

We know, time period $(T) = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{2\pi}{T}$

$$\omega_1 = \frac{2\pi}{T_1} \text{ and } \omega_2 = \frac{2\pi}{T_2}$$

Then, $$\frac{\omega_1}{\omega_2} = \frac{\frac{2\pi}{T_1}}{\frac{2\pi}{T_2}} = \frac{T_2}{T_1} \text{ .... (ii)}$$

From equation (i) and (ii)

$$\frac{T_2}{T_1} = \frac{1}{4} \Rightarrow T_2 = \frac{T}{4}$$

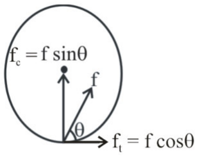
529. A child starts running from rest along a circular track of radius 'r' with constant tangential acceleration 'a'. After time 't' he feels that slipping of shoes on the ground has started. The coefficient of friction between shoes and the ground is [g = acceleration due to gravity]

(a) $\frac{\left[a^4t^4 + a^2r^2\right]}{rg}$ (b) $\frac{\left[a^2t^2 + a^2r^4\right]}{rg}$

(c) $\frac{\left[a^4t^4 - a^2r^2\right]^{\frac{1}{2}}}{rg}$ (d) $\frac{\left[a^4t^4 + a^2r^2\right]^{\frac{1}{2}}}{gr}$

MHT-CET 2020

Ans. (d) :



When child moves in a circular track, he is acted upon by two force as shown below.
Here, $f_c = f\sin\theta$ and $f_t = f\cos\theta$
As, f_c is the centripetal force and f_t is the tangential force.

@apna_pdf

Resultant force $(f_R) = \sqrt{(f\sin\theta)^2 + (f\cos\theta)^2}$

$$= \sqrt{\left(\frac{mv^2}{r}\right)^2 + (ma)^2}$$

Also, when the shoes starts slipping, the friction becomes equal to resultant force.

$\therefore\ f = f_R$

$$\mu mg = \sqrt{\left(\frac{mv^2}{r}\right)^2 + (ma)^2} \Rightarrow \mu mg = \sqrt{\frac{m^2v^4}{r^2} + m^2a^2}$$

$$\mu^2m^2g^2 = \frac{m^2v^4}{r^2} + m^2a^2 \Rightarrow \mu^2g^2 = \frac{(at)^4 + a^2r^2}{r^2} \quad \left[\begin{array}{l} \because a = \frac{v}{t} \\ v = at \end{array}\right]$$

$$\sqrt{\mu^2g^2} = \sqrt{\frac{a^4t^4 + a^2r^2}{r^2}} \Rightarrow \mu g = \frac{\left[a^4t^4 + a^2r^2\right]^{\frac{1}{2}}}{r}$$

$$\mu = \frac{\left[a^4t^4 + a^2r^2\right]^{\frac{1}{2}}}{gr}$$

530. A body is moving along a circular track of radius 100 m with velocity 20 m/s. Its tangential acceleration is 3 m/s^2, then its resultant acceleration will be

(a) 5 m/s^2 (b) 3 m/s^2

(c) 4 m/s^2 (d) 2 m/s^2

MHT-CET 2020

Ans. (a) : Given, tangential acceleration (a_t) = 3m/s^2, radius of track (r) = 100m, velocity (v) = 20 m/s

The radial acceleration of body $(a_r) = \frac{v^2}{r}$

$$a_r = \frac{(20)^2}{100} = \frac{400}{100}$$

$$a_r = 4 \text{ m/s}^2$$

Then the resultant of acceleration (a) = $\sqrt{(a_t)^2 + (a_r)^2}$

$$= \sqrt{(3)^2 + (4)^2} = \sqrt{9+16} = \sqrt{25}$$

$$a = 5\text{m/s}^2$$

531. A particle moves along a circular path with decreasing speed. Hence

(a) its angular momentum remains constant

(b) the direction of angular momentum remains constant

(c) its resultant acceleration is towards the centre

(d) it moves in a spiral path with decreasing radius

MHT-CET 2020

Ans. (b) : The angular momentum is given by

$$\vec{L} = \vec{r} \times \vec{p} = m\vec{r} \times \vec{v}$$

If speed decreases, then the magnitude of the angular momentum decrease but direction does not change.

The resultant acceleration is towards the centre only if the speed remains constant. Hence option (b) is wrong. It is given that the particle is moving in a circular path. Hence option (d) is wrong.

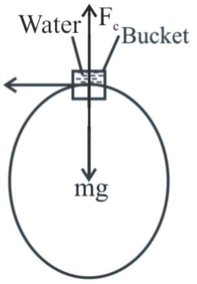
532. A bucket containing water is revolved in a vertical circle of radius 'r'. To prevent the water from falling down, the minimum frequency of revolution required is [g = acceleration due to gravity]

(a) $\frac{1}{2\pi}\sqrt{\frac{r}{g}}$ (b) $2\pi\sqrt{\frac{g}{r}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{g}{r}}$ (d) $\frac{2\pi g}{r}$

MHT-CET 2020

Ans. (c) :



For minimum velocity at the highest point we should have

$$mr\omega^2 = mg$$

$$\omega^2 = \frac{g}{r} \Rightarrow \omega = \sqrt{\frac{g}{r}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{r}} \qquad \{\because \omega = 2\pi f\}$$

533. A heavy mass is attached at one end of a thin wire and whirled in a vertical circle. The chances of breaking the wire are maximum when

(a) The wire makes an angle of 60° with the horizontal

(b) The mass is at the highest point of the circle

(c) The mass is at the lowest point of the circle

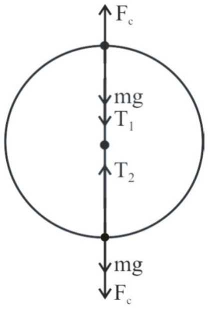
(d) The wire is horizontal

MHT-CET 2020

AP EAMCET (Medical)-1999

Manipur UGET-2011

Ans. (c) :



The body is rotating in a vertical circle.

So, at the bottom, $T_2 = mg + F_c$ …. (i)

At the top, $T_1 + mg = F_c$

$T_1 = F_c - mg$ …. (ii)

@apna_pdf

Comparing equation (i) and (ii), we get –

$T_2 > T_1$

So, tension is maximum at the lowest position of mass Hence, the chance of breaking is maximum at lowest point.

534. A particle of mass 'm' is rotating in a circle of radius 'r' having angular momentum 'L'. Then the centripetal force will be

(a) $\frac{L^2}{mr^2}$ (b) $\frac{L^2}{mr^2}$

(c) $\frac{L^2}{mr}$ (d) $\frac{L^2}{mr^3}$

MHT-CET 2020

Ans. (d) : Given, mass = m, circle radius = r, angular momentum = L

We know,

Centripetal force $(F_c) = \frac{mv^2}{r}$ …(i)

Angular momentum (L) = mvr

$$v = \frac{L}{mr} \quad \text{…(ii)}$$

Substituting the value of 'v' from equation (ii) to equation (i),

$$F_c = \frac{m}{r}\left(\frac{L}{mr}\right)^2$$

$$F_c = \frac{m}{r} \times \frac{L^2}{m^2r^2} \Rightarrow F_c = \frac{L^2}{mr^3}$$

535. A stone is tied at the end of a rope of length 1 m and whirled in a vertical circle. The ratio of velocity at highest point to lowest point will be

(a) $\sqrt{3}:1$ (b) $1:\sqrt{5}$

(c) $\sqrt{3}:\sqrt{5}$ (d) $\sqrt{5}:1$

MHT-CET 2020

Ans. (b) : We know,

Velocity at the highest point $(v_1) = \sqrt{rg}$

Velocity at the lowest point $(v_2) = \sqrt{5rg}$

Then, $\frac{v_1}{v_2} = \frac{1}{\sqrt{5}}$

536. A particle is moving in a circle of radius 'R' with constant speed 'V'. The magnitude of average acceleration after half revolution is

(a) $\frac{2V^2}{\pi R}$ (b) $\frac{2\pi}{RV^2}$

(c) $\frac{2V}{\pi R^2}$ (d) $\frac{2R}{\pi V}$

MHT-CET 2020

Ans. (a) : In a half revolution, change in momentum,

$$\Delta P = mV - m(-V) = 2mV \quad \text{…..(i)}$$

The amount of time it takes for a particle to complete a half revolution,

$$t = \frac{\pi R}{V} \quad \text{…….(ii)}$$

Average force (F) = Rate of change in momentum

$$= \frac{\Delta P}{t}$$

$$= \frac{2mV}{\frac{\pi R}{V}} \quad \text{[From equation (i) and (ii)]}$$

$$F = \frac{2mV^2}{\pi R}$$

$$ma = \frac{2mV^2}{\pi R} \quad \{\because F = ma\}$$

$$a = \frac{2V^2}{\pi R}$$

537. A particle of mass 'm' is performing U.C.M. along a circle of radius 'r'. The relation between centripetal acceleration 'a' and kinetic energy 'E' is given by

(a) $a = \left(\frac{2E}{mr}\right)^2$ (b) $a = \frac{E}{mr}$

(c) $a = \frac{2E}{mr}$ (d) $a = 2Em$

MHT-CET 2020, 2010

Ans. (c) : We know that

$$K.E = \frac{1}{2}I\omega^2 \quad \text{...... (i)}$$

and $\omega^2 = \frac{a}{r}$ ...... (ii)

from eqn (i) and (ii)

$$\therefore \quad E = \frac{I}{2} \times \frac{a}{r}$$

$$E = \frac{1}{2}mr^2 \times \frac{a}{r} \quad [I = mr^2]$$

$$E = \frac{1}{2}mr.a$$

$$a = \frac{2E}{mr}$$

538. A train has to negotiate a curve of radius 'r' m, the distance between the rails is 'ℓ' m and outer rail is raised above inner rail by distance of 'h' m. If the angle of banking is small, the safety speed limit on this banked road is

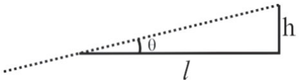
(a) $rg\frac{h}{\ell}$ (b) $\frac{\left(\frac{h}{\ell}\right)^2}{rg}$

(c) $\sqrt{rg\left(\frac{h}{\ell}\right)}$ (d) $\left(rg\frac{h}{\ell}\right)^2$

MHT-CET 2020

@apna_pdf

Ans. (c) : Given, radius of curve = r, distance between the rails = l, raised distance = h



At optimum speed,

Centrifugal force (F_c) = Friction force (F_s)

$$\frac{mv^2}{r} = \mu N = \mu mg$$

$$v^2 = \mu gr \Rightarrow v = \sqrt{\mu gr}$$

$$v = \sqrt{\tan\theta\, gr} \qquad \left(\because \tan\theta = \frac{h}{l}\right)$$

$$v = \sqrt{gr\frac{h}{l}}$$

539. The relative angular speed of hour hand and second hand of a clock is

(a) $\frac{359\pi}{21600}$ (b) $\frac{719\pi}{21600}$

(c) $\frac{9\pi}{21600}$ (d) $\frac{11\pi}{21600}$

MHT-CET 2020

Ans. (b) : Angular speed of hour hand,

$$\omega_h = \frac{2\pi}{12\times60\times60} \quad \text{......... (i)}$$

Angular speed of second hand,

$$\omega_s = \frac{2\pi}{60} \quad \text{........... (ii)}$$

From equation (i) and (ii), we get –

$$\omega_s = 720\omega_h$$

Relative angular speed of hour hand and second hand w.r.t second hand,

$$\frac{\omega_s - \omega_h}{\omega_s} = \frac{720-1}{720}$$

$$\Rightarrow \qquad \omega_s - \omega_h = \frac{719}{720}\omega_s$$

$$= \frac{719}{720}\times\frac{2\pi}{60} = \frac{719\pi}{21600}$$

540. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that they make complete circle in the same time t. The ratio of their centripetal force is

(a) $m_1 : m_2$ (b) $r_1 : r_2$

(c) 1:1 (d) $m_1r_1 : m_2r_2$

MHT-CET 2020

Ans. (d) : We know,

$$\text{Centripetal force } (F) = \frac{mv^2}{r}$$

$$\text{Then,} \quad F_1 = \frac{m_1v_1^2}{r_1}$$

$$\text{and} \quad F_2 = \frac{m_2v_2^2}{r_2}$$

$$\because \quad \frac{F_1}{F_2} = \frac{\frac{m_1v_1^2}{r_1}}{\frac{m_2v_2^2}{r_2}} = \frac{m_1v_1^2}{m_2v_2^2}\times\frac{r_2}{r_1} \quad \text{.......... (i)}$$

Given, time is same

$$\text{Then, Time} = \frac{\text{Distance}}{\text{Speed}}$$

$$t = \frac{2\pi r_1}{v_1} = \frac{2\pi r_2}{v_2}$$

$$\frac{v_1}{v_2} = \frac{r_1}{r_2} \quad \text{......... (ii)}$$

From equation (i) and (ii), we get –

$$\frac{F_1}{F_2} = \frac{m_1r_1^2}{m_2r_2^2}\times\frac{r_2}{r_1}$$

$$\frac{F_1}{F_2} = \frac{m_1r_1}{m_2r_2} \qquad \left[\frac{v_1}{v_2} = \frac{r_1}{r_2}\right]$$

$$F_1 : F_2 = m_1r_1 : m_2r_2$$

541. A flat curved road on highway has radius of curvature 400 m. A car rounds the curve at a speed of 24 m/s. The minimum value of coefficient of friction to prevent car from sliding is (take g = 10 m/s^2)

(a) 0.144 (b) 0.376

(c) 0.544 (d) 0.100

MHT-CET 2020

Ans. (a) : Given, radius of curvature (r) = 400 m

Speed (v) = 24 m/s

Friction force = Centripetal force

$$\text{So,} \quad \mu\, mg = \frac{mv^2}{r}$$

$$\mu = \frac{v^2}{rg}$$

$$\mu = \frac{(24)^2}{400\times10} = 0.144$$

542. What is the ratio of the angular speeds of second hand and the minute hand of a clock ?

(a) 1 : 60 (b) 1 : 2

(c) 12 : 1 (d) 60 : 1

MHT-CET 2019, 2020

Ans. (d) : We know that,

$$\omega = \frac{2\pi}{T}$$

$$\text{Angular speed of second hand } (\omega_s) = \frac{2\pi}{60}$$

$$\text{and angular speed of minute hand } (\omega_m) = \frac{2\pi}{60\times60}$$

@apna_pdf

So, $$\frac{\omega_s}{\omega_m} = \frac{\frac{2\pi}{60}}{\frac{2\pi}{60\times60}} = \frac{60\times60}{60} \Rightarrow \frac{\omega_s}{\omega_m} = 60$$

$\omega_s : \omega_m = 60 : 1$

543. In non-uniform circular motion, the ratio of tangential acceleration to radial acceleration is (r = radius of circle, v = speed and α = angular acceleration)

(a) $\frac{r\alpha}{v}$ (b) $\left(\frac{r}{v}\right)^2 \alpha$

(c) $\left(\frac{v}{r}\right)^2 \frac{1}{2}$ (d) $\left(\frac{v}{r}\right)^2 \alpha$

MHT-CET 2020

Ans. (b) : Tangential acceleration $(a_t) = \alpha r$

and radial acceleration $(a_r) = \frac{v^2}{r}$

The ratio of tangential and radial acceleration, we get–

$$\therefore \quad \frac{a_t}{a_r} = \frac{\alpha r}{\frac{v^2}{r}} = \frac{\alpha r^2}{v^2}$$

$$\frac{a_t}{a_r} = \left(\frac{r}{v}\right)^2 \alpha$$

544. A particle moves along a circular path of radius 'r' with uniform speed 'V'. The angle described by the particle in one second is

(a) $V^2 r$ (b) $\frac{r}{V}$

(c) Vr (d) $\frac{V}{r}$

MHT-CET 2020

Ans. (d) : Given, uniform speed = V, circular path of radius = r

We know that, angular velocity $(\omega) = \frac{V}{r}$

and angular displacement $(\theta) = \omega t$

Then, angle described by the particle in 1 sec.

$$\theta = \frac{V}{r}$$

545. The maximum velocity with which vehicle can safety travel along banked road does NOT depend upon

(a) mass of the vehicle

(b) acceleration due to gravity at a place

(c) radius of the curved road

(d) angle of banking

MHT-CET 2020, 2005

Ans. (a) : We know, the maximum permissible velocity on a banked road

$$v_{max} = \sqrt{\frac{rg(\mu_s + \tan\theta)}{(1-\mu_s \tan\theta)}}$$

Where, r = radius of curvature,
θ = angle of banking
μ_s = coefficient of friction

546. What is the least radius of curve on a horizontal road, at which a vehicle can travel with a speed of 36 km/hr at an angle of inclination 45°?
[g = 10 m/s^2, tan 45° = 1]

(a) 15 m (b) 20 m

(c) 10 m (d) 25 m

MHT-CET 2020

Ans. (c) : Given,

Vehicle speed (v) = 36 km/hr $\times \frac{5}{18} = 10\,m/s$

Angle, (θ)=45°

We know,

Centripetal force = Frictional force

$$\frac{mv^2}{r} = \mu mg \qquad (\mu = \tan\theta)$$

$$\frac{v^2}{r\times g} = \tan\theta$$

$$r = \frac{v^2}{g\times\tan\theta}$$

$$r = \frac{(10)^2}{10\times\tan 45^\circ} = \frac{100}{10\times1} = 10\text{ m}$$

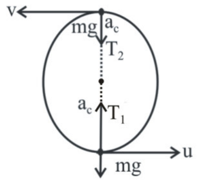
547. A particle is performing vertical circular motion. The difference in tension at lowest and highest point is

(a) 8 mg (b) 2 mg

(c) 6 mg (d) 4 mg

MHT-CET 2020
AIIMS - 2001
TS EAMCET-29.09.2020 Shift-II

Ans. (c) : According to the question



Let, T_1 = Tension at lowest point
T_2 = Tension at highest point
v = Velocity at highest point
u = Velocity at lowest point

At the lowest point–

$$T_1 = \frac{mu^2}{R} + mg \qquad .....(i)$$

At the highest point–

$$T_2 = \frac{mv^2}{R} - mg \qquad .....(ii)$$

Substracting equation (i) from (ii)

$$(T_1 - T_2) = \left(\frac{mu^2}{R} + mg\right) - \left(\frac{mv^2}{R} - mg\right)$$

@apna_pdf

$$(T_1 - T_2) = \frac{m}{R}(u^2 - v^2) + 2mg \quad \text{--------} \text{ (iii)}$$

From conservation of energy,

$$(P.E + K.E)_{Lowest} = (P.E + K.E)_{Highest}$$

$$0 + \frac{1}{2}mu^2 = mg2R + \frac{1}{2}mv^2$$

$$\frac{1}{2}m(u^2 - v^2) = mg2R$$

$$u^2 - v^2 = 4gR \text{ ....(iv)}$$

Putting these value in equation (iii)

$$T_1 - T_2 = \frac{m}{R} \times 4gR + 2mg$$

$$= 4\text{ mg} + 2\text{mg} = 6\text{ mg}$$

548. A particle is moving along the circular path with constant speed and centripetal acceleration 'a'. If the speed is doubled, the ratio of its acceleration after and before the change is

(a) 4 : 1 (b) 2 : 1

(c) 3 : 1 (d) 1 : 4

MHT-CET 2019

J&K CET-2008

Ans. (a) : We know,

Centripetal acceleration $(a) = \frac{v^2}{r}$

Acceleration before change, $a = \frac{v^2}{r}$

and acceleration after change, $a_2 = \frac{(2v)^2}{r} = \frac{4v^2}{r}$

Ratio of both acceleration,

$$\frac{a_2}{a} = \frac{4v^2/r}{v^2/r} \Rightarrow \frac{a_2}{a} = \frac{4}{1}$$

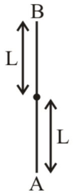
549. A rod of length 'L' is hung from its one end and a mass 'm' is attached to its free end. What tangential velocity must be imparted to 'm'. So that it reaches the top of the vertical circle? (g = acceleration due to gravity)

(a) $4\sqrt{gL}$ (b) $2\sqrt{gL}$

(c) $5\sqrt{gL}$ (d) $3\sqrt{gL}$

MHT-CET 2020

Ans. (b) : According to the question



From conservation of energy,

$$(K.E)_A + (P.E)_A = (K.E)_B + (P.E)_B$$

$$\frac{1}{2}mv^2 + 0 = 0 + mg \times (2L)$$

$$\frac{1}{2}mv^2 = mg \times 2L$$

$$\frac{1}{2}v^2 = 2gL$$

$$v^2 = 4gL$$

$$v = 2\sqrt{gL}$$

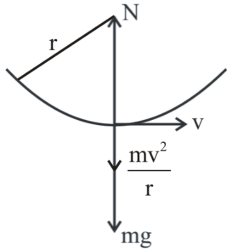
550. The overbridge of a canal is in the form of a concave circular arc of radius 'r'. The thrust at the lowest point is (m = mass of the vehicle, v = velocity of the vehicle, g = acceleration due to gravity).

(a) $mg \div mv^2/r$ (b) $\left(mg + \frac{mv^2}{r}\right)$

(c) $\left(mg - \frac{mv^2}{r}\right)$ (d) $mg \times \frac{mv^2}{r}$

MHT-CET 2020

Ans. (b) : According to the question



From the above figure–

Let N be the thrust force applied by the bridge by equation of circular motion

$$\therefore \quad \frac{mv^2}{r} = N - mg$$

$$N = \frac{mv^2}{r} + mg$$

551. A particle of mass 4 gram moves along a circle of radius $\frac{10^2}{2\pi}$ cm with constant tangential acceleration. After beginning of the motion, by the end of second revolution, the kinetic energy of the particle becomes 18×10^{-5} J. Magnitude of tangential acceleration is

(a) 2.25×10^{-6} m/s^2 (b) 2.25×10^{-5} m/s^2

(c) 2.25×10^{-4} m/s^2 (d) 2.25×10^{-3} m/s^2

MHT-CET 2020

Ans. (c) : Given, mass (m) = 4×10^{-3}kg, circle of radius (r) = $\frac{10^2}{2\pi}$ cm, kinetic energy (K.E) = 18×10^{-5} J

Let, velocity of particle = v

$$\because \quad K.E. = \frac{1}{2}mv^2$$

$$18 \times 10^{-5} = \frac{1}{2} \times 4 \times 10^{-3} \times v^2$$

@apna_pdf

$$v^2 = \frac{2\times18\times10^{-5}}{4\times10^{-3}} = 9\times10^{-2}\ (m/s)$$

$$v = 3\times10^{-1}\ m/s$$

Initial velocity of particle (u) = 0 m/s

Total distance covered (s) = 2(2πr) = 4πr

We know,

$$v^2 = u^2 + 2as$$

$$v^2 = 2as$$

$$a = \frac{v^2}{2s}$$

$$a = \frac{\left(3\times10^{-1}\right)^2\times2\pi}{2\times4\pi\times10^2} = \frac{9\times10^{-4}}{4}$$

$$a = 2.25\times10^{-4}\ m/s^2$$

552. A coin kept at a distance 'r_1' cm from the axis of rotation of a turn table, just begins to slip when the turntable rotates at an angular speed of 'ω_1' rad/s. If this distance is tripled, then at what angular speed of the turntable, will the coin begin to slip ?

(a) $3\omega_1$rad/s (b) $\sqrt{3}\,\omega_1$rad/s

(c) $\frac{\omega_1}{\sqrt{3}}$rad/s (d) $\frac{\omega_1}{3}$rad/s

MHT-CET 2019

Ans. (c) : We know, the relation

$$m_1r_1\omega_1^2 = m_2r_2\omega_2^2 \qquad (F_s = m\omega^2r)$$

According to the question,

$$mr_1\omega_1^2 = 3mr_1\omega_2^2 \qquad (r_2 = 3r_1)$$

$$\therefore \qquad \omega_2^2 = \frac{\omega_1^2}{3}$$

$$\omega_2 = \frac{\omega_1}{\sqrt{3}}\ \text{rad/s}$$

553. The real force 'F' acting on a particle of mass 'm' performing circular motion acts along the radius of circle 'r' and is directed towards the centre of circle. The square root of magnitude of such force is (τ = periodic time)

(a) $\frac{2\pi}{T}\sqrt{mr}$ (b) $\frac{T^2mr}{4\pi}$

(c) $\frac{2\pi T}{\sqrt{mr}}$ (d) $\frac{Tmr}{4\pi}$

MHT-CET 2019

Ans. (a) : For circular motion,

$$\text{Force (F)} = \frac{m\times v^2}{r}$$

Then, $F = mr\omega^2 \qquad (v = r\omega)$

$$F = m.r.\left(\frac{2\pi}{T}\right)^2 \qquad \left(\omega = \frac{2\pi}{T}\right)$$

$$\sqrt{F} = \sqrt{m.r}\,\frac{2\pi}{T} \Rightarrow \sqrt{F} = \frac{2\pi}{T}\sqrt{m.r}$$

554. A mass attached to one end of a string crosses top-most point on a vertical circle with critical speed. Its centripetal acceleration when string becomes horizontal will be (g = gravitational acceleration)

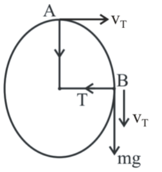
(a) g (b) 3g

(c) 4g (d) 6g

MHT-CET 2018

Ans. (b) : We know, velocity of particle at top most point on vertical circle,

$$v_T = \sqrt{3rg} \ \ .... (i)$$



But centripetal acceleration $(a_c) = \frac{v_T^2}{r}$

$$\therefore \qquad a_c = \frac{\left(\sqrt{3rg}\right)^2}{r} \qquad \text{[From equation (i)]}$$

$$a_c = \frac{3rg}{r} \Rightarrow a_c = 3g$$

555. A particle moves along a circle of radius 'r' with constant tangential acceleration. If the velocity of the particle is 'v' at the end of second revolution, after the revolution has started then the tangential acceleration is

(a) $\frac{v^2}{8\pi r}$ (b) $\frac{v^2}{6\pi r}$

(c) $\frac{v^2}{4\pi r}$ (d) $\frac{v^2}{2\pi r}$

MHT-CET 2016

Ans. (a) : Given, initial speed of the particle (u) = 0

Final speed of the particle = v

Distance covering in 2 revolution (s) = 2 × 2πr = 4πr

Applying equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2\times a\times4\pi r$$

$$a = \frac{v^2}{8\pi r}$$

556. A particle of mass 'm' is moving in circular path of constant radius 'r' such that centripetal acceleration is varying with time 't' as $K^2\ r\ t^2$ where K is a constant. The power delivered to the particle by the force acting on it is

(a) $m^2\,K^2\,r^2\,t^2$ (b) $m\,K^2\,r^2\,t$

(c) $m\,K^2r\,t^2$ (d) $m\,K\,r^2\,t$

MHT-CET 2015
SCRA-2009
UP CPMT-2013
TS EAMCET (Medical) - 2015
JEE Mains - 28.06.2022 Shift-I

@apna_pdf

Ans. (b) : Given,
Centripetal acceleration (a_c) = K^2rt^2 .....(i)
And we know,
Centripetal accelerate (a_c) = $\frac{v^2}{r}$ .....(ii)
Comparing equation (i) and (ii),

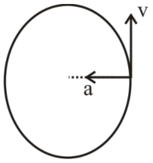
$$\frac{v^2}{r} = K^2rt^2$$
$$v^2 = K^2r^2t^2$$
$$v = Krt$$

Tangential acceleration (a) = $\frac{dv}{dt} = Kr$
Then, Force (F) = ma = mKr
So, Power (P) = F.v
P = mKr × Krt
P = mK^2r^2t

557. The angle between velocity and acceleration of a particle describing uniform circular motion is:
(a) 180^0 (b) 90^0
(c) 45^0 (d) 60^0

Karnataka CET-2017
MHT CET - 2020
Kerala CEE- 2013

Ans. (b) : The velocity of particle representing uniform circular motion is always perpendicular to centripetal acceleration. Because the particles tangential acceleration is zero.



Therefore, the angle between velocity and acceleration for an object moving in uniform circular motion is 90°.

558. An aeroplane executes a horizontal loop at a speed of 720 km/h with its wings banked at 45^0. What is the radius of the loop ? Take g = $10ms^{-2}$.
(a) 4 km (b) 4.5 km
(c) 7.2 km (d) 2 km

Karnataka CET-2014

Ans. (a) : Given, angle of banking (θ) = 45°, speed of the aeroplane (v) = 720 km/h = $720 \times \frac{5}{18} = 200\,m/s$
For radius r of the loop, We have the relation,

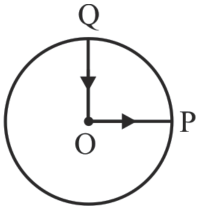
$$\tan\theta = \frac{v^2}{rg}$$
$$r = \frac{v^2}{g\tan\theta}$$
$$r = \frac{(200)^2}{10 \times \tan 45^0} \quad (\because \theta = 45^o)$$
$$r = \frac{40000}{10} = 4000\,m$$
$$r = 4\text{ km}$$

559. The circular motion of a particle with constant speed is :
(a) Neither periodic nor SHM
(b) Periodic but not SHM
(c) SHM but not periodic
(d) Periodic and also SHM

Karnataka CET-2012

Ans. (b) : A particle with constant speed repeats its motion after a regular interval of time but does not oscillate about a fixed point in circular motion. So, the circular motion of a particle with constant speed is periodic but not SHM.

560. A cyclist starts from the centre O of a circular park of radius one kilometre, reaches the edge P of the park, then cycles along the circumference and returns to the centre along QO as shown in the figure. If the round trip takes ten minutes, the net displacement and average speed of the cyclist (in metre and kilometre per hour) is :



(a) 0, 1 (b) $\frac{\pi+4}{2}, 0$
(c) $21.4, \frac{\pi+4}{2}$ (d) 0, 21.4

Karnataka CET-2006

Ans. (d) : Since the net displacement of the cyclist is zero then the average velocity will also be zero.
by diagram, OP = Radius = 1 km, PQ = Rθ = 1 × π/2

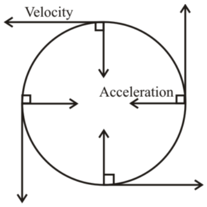
$$\text{Average speed of the cyclist} = \frac{\text{Total distance travelled}}{\text{Total time}}$$
$$= \frac{OP + PQ + QO}{10}\,km/min$$
$$= \frac{1 + \frac{\pi}{2} \times 1 + 1}{10}\,km/min$$
$$= \frac{4+\pi}{20} \times 60\,km/hr$$
$$= 7.14 \times 3\text{ km/hr} = 21.4\text{ km/hr}$$

561. The acceleration of an object moving in a circle of radius R with uniform speed v is
(a) $\frac{v^2}{R}$ (b) $\frac{v^2}{2R}$
(c) $\frac{2v^2}{R}$ (d) $\frac{3v^2}{2R}$

J&K CET- 2011

@apna_pdf

Ans. (a) : We know that, $v = \omega r$



$$a_C = \frac{dv}{dt} = \frac{d}{dt}(\omega r) \quad (a_C = \text{centripetal acceleration})$$

$$a_C = \omega\frac{dr}{dt} \quad (\omega \text{ is constant })$$

$$a_C = \omega \times v \quad \left\{\because \frac{dr}{dt} = v\right\}$$

$$= \frac{v}{R}.v$$

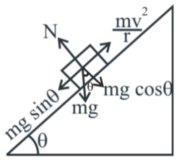
$$a_C = \frac{v^2}{R}$$

562. If a car is to travel with a speed v along the frictionless, banked circular track of radius r, the required angle of banking so that the car does skid is

(a) $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$
(b) $\theta = \tan^{-1}\left(\frac{v}{rg}\right)$
(c) $\theta = \tan^{-1}\left(\frac{r^2}{vg}\right)$
(d) $\theta < \tan^{-1}\left(\frac{v^2}{rg}\right)$

J&K CET- 2010, 2008

Ans. (a) :



Let θ is the angle of banking
In horizontal,

$$mg \sin\theta = \frac{mv^2}{r} \quad ....(i)$$

In vertical,

$$mg \cos\theta = mg \quad ....(ii)$$

Dividing equation (i) by equation (ii)

$$\frac{mg \sin\theta}{mg \cos\theta} = \frac{mv^2}{r \times mg}$$

$$\tan\theta = \frac{v^2}{rg} \Rightarrow \theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$

563. A particle is describing uniform circular motion. Its acceleration is

(a) Along the radius of circular path pointing towards the center
(b) Along the tangent to the circular path
(c) Along the radius of the circular path pointing away from the centre
(d) Zero

J&K CET- 2009

Ans. (a) Acceleration acting on the object undergoing uniform circular motion is called centripetal acceleration. It always acts on the object along the radius towards the centre of circular path.

564. A stone tied to one end of rope and rotated in a circular motion. If the string suddenly breaks, then the stone travels in

(a) Perpendicular direction
(b) In direction of centrifugal force
(c) Towards centrifugal force
(d) Tangential direction

J&K CET- 2007

Ans. (d) If the string suddenly breaks then centripetal force will be zero. Only tangential force will be present then the stone travels in tangential direction.

565. Angle of banking for a vehicle speed of 10 m/s for a radius of curvature 10 m is (assume $g = 10 m/s^2$)

(a) 30°
(b) $\tan^{-1}(1/2)$
(c) 60°
(d) 45°

J&K CET- 1998, 2002, 2003, 2006
Kerala CEE - 2004, 2015
JCECE - 2005

Ans. (d) : Given, v = 10 m/s, r = 10 m, $g = 10 m/s^2$
We know,
Angle of banking,

$$\tan\theta = \frac{v^2}{rg} \Rightarrow \tan\theta = \frac{10 \times 10}{10 \times 10} = 1$$

$$\tan\theta = \tan 45^0$$

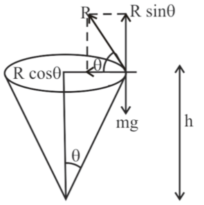
$$\theta = 45°$$

566. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of 0.5 m/s. What is the height of the plane of circle from vertex of the funnel?

(a) 0.25 cm
(b) 2 cm
(c) 4 cm
(d) 2.5 cm

J&K CET- 2005
UPSEE - 2012
MHT CET-2020

Ans. (d) : Given that, particle is moving in circular path
So, figure



$$mg = R \sin\theta \ .... \ (i)$$

$$\frac{mv^2}{r} = R\cos\theta \ .... \ (ii)$$

From equation (i) and (ii)

$$\therefore \quad \tan\theta = \frac{rg}{v^2} \text{ but } \tan\theta = \frac{r}{h}$$

$$h = \frac{v^2}{g} = \frac{(0.5)^2}{10} = 0.025\,m \ = 2.5 \text{ cm}$$

@apna_pdf

567. A cyclist covers a circular path 34.3 m long in $\sqrt{22}$ sec. The angle of inclination of the cyclist is (Given g = 9.8 m/s^2)

(a) 50° (b) 45°
(c) 30° (d) 60°

J&K CET- 2000

Ans. (b) : Let r be the radius of circular path,

The length of path = $2\pi r = 34.3\text{m}$, $t = \sqrt{22}$ sec

$$r = \frac{34.3}{2\pi}\text{m}$$

Then, $$\text{Velocity} = \frac{\text{Length of path}}{\text{Time}} = \frac{34.3}{\sqrt{22}}$$

$$\tan\theta = \frac{v^2}{rg} = \frac{\left(\frac{34.3}{\sqrt{22}}\right)^2}{\frac{34.3}{2\pi}\times 9.8} = 0.999$$

$$\tan\theta \approx 1 = \tan 45°$$

So, $\theta = 45°$

568. A car of mass 1000 kg moves on a circular road with speed of 20 m/s. Its direction changes by 90° after travelling 628 m on the road. The centripetal force acting on the car is

(a) 7500 N (b) 750 N
(c) 1000 N (d) 1500 N

J&K CET- 1997

Ans. (c) : Given, v = 20 m/s, m = 1000 kg

Since it changes its direction after travelling 628 m

So, $$r \times \frac{\pi}{2} = 628$$

$$r = 399.79 \approx 400\,\text{m}$$

Then, $$\text{Centripetal force} = \frac{mv^2}{r}$$

$$= \frac{1000\times(20)^2}{400} = \frac{1000\times 400}{400} = 1000\,\text{N}$$

569. A particle moving in uniform circular motion has its radius and tangential speed doubled. Its centripetal acceleration is then

(a) tripled (b) the same as before
(c) doubled (d) become four times

J&K CET- 1997

Ans. (c) : Given, $v_2 = 2v_1$, $R_2 = 2R_1$

We know that,

$$\text{Centripetal acceleration } (a) = \frac{v^2}{R}$$

Now, $$\frac{a_1}{a_2} = \frac{v_1^2}{R_1}\times\frac{R_2}{v_2^2} = \left(\frac{v_1}{v_2}\right)^2 \times \frac{R_2}{R_1}$$

$$\frac{a_1}{a_2} = \left(\frac{v_1}{2v_1}\right)^2 \times \left(\frac{2R_1}{R_1}\right)$$

$$\frac{a_1}{a_2} = \frac{1}{2}$$

$$a_2 = 2a_1$$

So, its acceleration will be doubled.

570. Uniform circular motion is an example of

(a) constant speed motion
(b) constant velocity motion
(c) non-accelerated motion
(d) zero accelerated motion

J&K-CET-2013

Ans. (a) : Uniform circular motion is an example of constant speed motion.

In uniform circular motion, magnitude of velocity remains unchanged but there is change in the direction of velocity vector.

571. The velocity-time graph of a particle comes out to be a non-linear curve. The motion is

(a) uniform velocity motion
(b) uniformly accelerated motion
(c) non-uniform accelerated motion
(d) nothing can be said about the motion

J&K-CET-2013

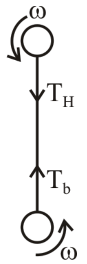
Ans. (c) : Velocity-time graph gives the instantaneous value of velocity at any instant. For non-uniform accelerated motion, v-t graph is non-linear.

572. A brick of mass m, tied to a rope, is being whirled in a vertical circle, with a uniform speed. The tension in the rope is

(a) the same throughout
(b) largest when the brick is at the highest point of the circular path and smallest when it is at the lowest point.
(c) largest when the rope is horizontal and smallest when it is vertical
(d) largest when the brick is at the lowest point and smallest when it is at the highest point

J&K-CET-2012

Ans. (d) : When the brick is following a circular path in vertical direction then it is being acted by two forces, one due to the motion of brick that is centrifugal force and other is due to the action of gravity that is force of gravity.



$$T_H + mg = m\omega^2 r$$
$$T_L - mg = m\omega^2 r$$
$$T_L > T_H$$

Tension in largest when the brick is at the lowest point and smallest when it is at the highest point.

@apna_pdf

573. A particle moves with a uniform speed v and time period T in a circular path of radius r. If the speed of the particle is doubled, its new time period is

(a) T (b) $\frac{T}{2}$

(c) 2T (d) $\frac{T}{4}$

J&K-CET-2016

Ans. (b) : Time period $(T) = \frac{2\pi r}{v}$ ….. (i)

When the speed of particle is doubled, its new time period,

$$T' = \frac{2\pi r}{2v} = \frac{1}{2}\left(\frac{2\pi r}{v}\right)$$

By using equation (i), we get–

$$T' = \frac{T}{2}$$

574. If $x = 5t + 3t^2$ and $y = 4t$ are the x and y co-ordinates of a particle at any time t second where x and y are in metre, then the acceleration of the particle

(a) Is zero throughout its motion

(b) Is a constant throughout its motion

(c) Depends only on its y component

(d) Varies along both x and y direction

J&K-CET-2016

Ans. (b) : Given that, $x = 5t + 3t^2$, $y = 4t$

$$v_x = \frac{dx}{dt} = \frac{d}{dt}\left(5t+3t^2\right) = 5+6t$$

$$v_y = \frac{dy}{dt} = \frac{d}{dt}(4t) = 4$$

$$a_x = \frac{dv_x}{dt} = \frac{d}{dt}(5+6t) = 6$$

$$a_y = \frac{dv_y}{dt} = \frac{d}{dt}(4) = 0$$

Then, the acceleration of the particle is –

$$a = \sqrt{a_X^2 + a_Y^2}$$

$$= \sqrt{(6)^2 + (0)^2} = 6$$

So, it is constant through its motion.

575. Two particles are performing uniform circular motion about a centre of two concentric circles of radii 'r_1', and 'r_2', respectively. The two particles and the centre of circles lie on a straight line during the motion, then the ratio of their angular velocities will be

(a) 3 : 1 (b) 2 : 1

(c) 0.5 : 1 (d) 1 : 1

MHT-CET 2020

Ans. (d) : Angular velocity $(\omega) = \frac{d\theta}{dt}\,\text{rad/sec}$

Where, $d\theta$ = change in angular displacement

dt = change in time

So, angular velocity in concentric circles of radii r_1 is

$$\omega_1 = \frac{\theta_1}{t_1} = \frac{\theta}{t} \text{ ….. (i)}$$

Angular velocity in concentric circles of radii r_2 is

$$\omega_2 = \frac{\theta_2}{t_2} = \frac{\theta}{t} \text{ …… (ii)}$$

From equation (i) and (ii), we get

$$\frac{\omega_1}{\omega_2} = \frac{\frac{\theta}{t}}{\frac{\theta}{t}} = \frac{1}{1}$$

$\omega_1 : \omega_2 = 1 : 1$

576. A particle is moving in uniform circular motion with speed 'V' and radius 'R'. The angular acceleration of the particle is

(a) $\frac{V^2}{R}$ along tangent to the circle.

(b) zero

(c) $\frac{V^2}{R}$ along the radius towards the centre of the circle

(d) $\frac{V^2}{R}$ perpendicular to the plane of the circle

MHT-CET 2020

Ans. (b) : In uniform circular motion, the angular velocity of the particle does not change, i.e. $d\omega = 0$

Angular acceleration $(\alpha) = \frac{d\omega}{dt}$

$$d\omega = 0$$

$$\alpha = 0$$

So, its angular acceleration is zero.

577. A stone of mass 3 kg attached at one end of a 2m long string is whirled in horizontal circle. The string makes an angle of 45° with the vertical then the centripetal force acting on the string is ($g = 10\ \text{m/s}^2$, $\tan 45° = 1$)

(a) 20 N (b) 30 N (c) 10 N (d) 40 N

MHT-CET 2020

Ans. (a) : Given that, Mass of stone (m) = 3kg

Length of string (l) = 2m, Angle (θ)= 45°

In a conical pendulum, $\tan\theta = \frac{v^2}{rg}$

$$\therefore \quad \frac{v^2}{r} = g\tan\theta = 10\times\tan 45^\circ = 10\times 1 = 10\,\text{ms}^{-2}$$

Now, centripetal force (F) $= \frac{mv^2}{r} = 2\times 10 = 20\,\text{N}$

578. A body of mass 'm' is moving along a circle of radius 'r' with linear speed 'v'. Now, to change the linear speed to $\frac{v}{2}$ and to move it along the circle of radius '4r', required change in the centripetal force of the body is

@apna_pdf

(a) decrease by $\frac{15}{16}$ (b) decrease by $\frac{5}{16}$

(c) increase by $\frac{9}{16}$ (d) increase by $\frac{11}{16}$

MHT-CET 2020

Ans. (a) : Given that, mass = m, radius of circle = r, Linear speed = v

Then, Centripetal force $(F_1) = \frac{mv^2}{r}$

When change in linear speed to $\left(v_2 = \frac{v}{2}\right)$, and radius $(r_2) = 4r$

$$F_2 = \frac{mv_2^2}{r_2}$$

$$F_2 = \frac{m}{4r} \cdot \frac{v^2}{4} = \frac{1}{16} \cdot \frac{mv^2}{r} = \frac{F_1}{16}$$

So, $F_1 - F_2 = F_1 - \frac{F_1}{16}$

Now, $F_1 - F_2 = \frac{15}{16} F_1$

579. At any instant, the magnitude of the centripetal force on a particle of mass 'm' performing circular motion is given by (ω = angular velocity and v = linear velocity of the particle)

(a) $\frac{m\omega^2}{v}$ (b) $\frac{mv^2}{\omega}$

(c) $\frac{m^2\omega^2}{v}$ (d) $m\omega v$

MHT-CET 2020

Ans. (d) : Given that, mass = m, angular velocity = ω, linear velocity = v

Now, centripetal force (F) = $\frac{mv^2}{r} = mr\omega^2 \quad (\because v = r\omega)$

$$F = mv\omega$$

580. Mass of 0.5 kg is attached to a string moving in horizontal circle with angular velocity 10 cycle/min. Keeping the radius constant, tension in the string is made 4 times by increasing angular velocity 'ω'. The value 'ω' of that mass will be

(a) $\frac{1}{4}$ cycle/s (b) $\frac{1}{2}$ cycle/s

(c) $\frac{1}{5}$ cycle/s (d) $\frac{1}{3}$ cycle/s

MHT-CET 2020

Ans. (d) : Given, Mass (m) = 0.5 kg

Angular velocity (ω_1) = 10 cycle/min

Tension $(T_1) = T$, $T_2 = 4T$

Angular velocity (ω_2) = ?

Now, tension $(T) = mr\omega^2$

$\therefore \quad T \propto \omega^2$

$$\therefore \quad \frac{\omega_2}{\omega_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{4T}{T}} = \sqrt{4} = 2$$

So, $\omega_2 = 2\omega_1$ = 2 × 10 cycle/min

= 20 cycle/min

$= \frac{20}{60}$ cycle/s $= \frac{1}{3}$ cycle/s

581. A ball of mass 'm' is attached to the free end of an inextensible string of length 'ℓ'. Let 'T' be the tension in the string. The ball is moving in horizontal circular path about the vertical axis. The angular velocity of the ball at any particular instant will be

(a) $\sqrt{\frac{Tm}{\ell}}$ (b) $\sqrt{\frac{T\ell}{m}}$

(c) $\sqrt{\frac{T}{m\ell}}$ (d) $\sqrt{\frac{m\ell}{T}}$

MHT-CET 2020

Ans. (c) : If 'T' be the tension in the string and ball is moving in horizontal circular path about the vertical axis.

So, tension $(T) = ml\omega^2$

$$\therefore \quad \omega = \sqrt{\frac{T}{ml}}$$

582. Two cars of masses 'm_1', and 'm_2' are moving in the circles of radii 'r_1' and 'r_2' respectively. Their angular speed 'ω_1' and 'ω_2' are such that they both complete one revolution in the same time 't'. The ratio of linear speed of 'm_1' to the linear speed of 'm_2' is

(a) $\omega_1^2 : \omega_2^2$ (b) $T_1^2 : T_2^2$

(c) $r_1 : r_2$ (d) $m_1 : m_2$

MHT-CET 2020

Ans. (c) : Given that, mass of two cars = m_1 and m_2, radii of circles = r_1 and r_2, angular speed = ω_1 and ω_2, Time is same for both two cars to complete one revolution

So, $\omega_1 = \omega_2 = \frac{2\pi}{t}$

$$v = r\omega$$

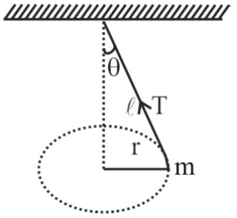
$$v = r \times \left(\frac{2\pi}{t}\right)$$

$$\frac{v_1}{r_1} = \frac{v_2}{r_2}$$

$$\therefore \quad \frac{v_1}{v_2} = \frac{r_1}{r_2}$$

583. A string of length 'ℓ' fixed at one end carries a mass 'm' at the other end. The string makes $\frac{2}{\pi}$ revolutions/second around the vertical axis through the fixed end as shown in figure. The tension 'T' in the string is

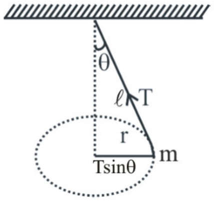
@apna_pdf



(a) 16 mℓ (b) 3 mℓ
(c) 18 mℓ (d) 9 mℓ

MHT-CET 2020

Ans. (a) : Given that, $n = \frac{2}{\pi}$ revolutions per second



Then, $T\sin\theta = m\omega^2 r$ ……. (i)

$T\sin\theta = m\omega^2 l\sin\theta$ ……. (ii)

From equation (i) and (ii), we get–

$$T = m\omega^2 l$$

$$= m\,(2\pi n)^2\, l \;= m4\pi^2 n^2 l$$

$$= m\times 4\pi^2\left(\frac{2}{\pi}\right)^2 l \;= m\times 4\pi^2\times\frac{4}{\pi^2}\times l$$

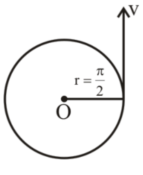
$$T = 16\text{ m}l$$

584. A particle performing U.C.M. of radius $\frac{\pi}{2}$m makes 'x' revolutions in time 't'. Its tangential velocity is

(a) $\frac{\pi x}{t^2}$ (b) $\frac{\pi x^2}{t}$
(c) $\frac{\pi^2 x}{t}$ (d) $\frac{\pi t}{x^2}$

MHT-CET 2020

Ans. (c) : Given, radius (r) = $\frac{\pi}{2}$, revolution = $\frac{x}{t}$



∴ Frequency (f) = $\frac{x}{t}$

∵ Angular velocity (ω) = 2πf

$$\omega = 2\pi\times\frac{x}{t}$$

∴ Tangential velocity (v) = rω

$$v = \frac{\pi}{2}\times\frac{2\pi x}{t} \Rightarrow v = \frac{\pi^2 x}{t}$$

585. A mass 'm' is tied to one end of a spring and whirled in a horizontal circle with constant angular velocity. The elongation in the spring is 1 cm. If the angular speed is doubled, the elongation in the spring is 6 cm. The original length of the spring is

(a) 3 cm (b) 12 cm
(c) 6 cm (d) 9 cm

MHT-CET 2020

Ans. (d): Given, x_1 = 1cm, x_2 = 6cm, $\omega_1 = \omega$, $\omega_2 = 2\omega$

Let K be the spring constant and L cm be the initial length.

So, $m(L+x_1)\omega_1^2 = Kx_1$ …… (i)

$m(L+x_2)\omega_2^2 = Kx_2$ …… (ii)

Now, taking ratio of equation (i) and (ii), we get

$$\frac{m(L+x_1)\omega_1^2}{m(L+x_2)\omega_2^2} = \frac{Kx_1}{Kx_2}$$

$$\left(\frac{L+x_1}{L+x_2}\right)\times\frac{\omega_1^2}{\omega_2^2} = \frac{x_1}{x_2}$$

$$\left(\frac{L+x_1}{L+x_2}\right) = \frac{x_1}{x_2}\times\frac{\omega_2^2}{\omega_1^2} \Rightarrow \left(\frac{L+x_1}{L+x_2}\right) = \frac{1}{6}\times\frac{(2\omega)^2}{\omega^2}$$

$$\left(\frac{L+1}{L+6}\right) = \frac{2}{3}$$

$$3(L+1) = 2(L+6)$$

$$3L+3 = 2L+12$$

$$L = 9\text{ cm.}$$

586. A particle is performing U.C.M. along the circumference of a circle of diameter 50 cm with frequency 2 Hz. The acceleration of the particle in m/s^2 is

(a) $2\pi^2$ (b) $4\pi^2$
(c) $8\pi^2$ (d) π^2

MHT-CET 2019

Ans. (b) : Given that, diameter of circle = 50 cm,

Now, radius (r) = 25 cm = 25 × 10^{-2} m

Frequency (f) = 2 Hz

Now, acceleration (a) = $r\omega^2$

$$a = (2\pi f)^2\times r \qquad (\because \omega = 2\pi f)$$

$$a = 4\pi^2 f^2\times r$$

$$a = 4\pi^2\times 4\times 25\times 10^{-2}$$

$$a = 4\pi^2$$

587. In U.C.M. when time interval δt→0, the angle between change in velocity (δv) and linear velocity (v) will be

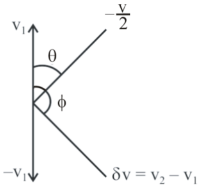
(a) 0^0 (b) 45^0
(c) 90^0 (d) 180^0

MHT-CET 2019

@apna_pdf

Ans. (c) : Direction of change in velocity is –

$$\phi = \frac{180° - \theta}{2} = 90° - \frac{\theta}{2} \ldots\ldots \text{(i)}$$



For small intervals as, $\delta t \to 0$, then the angle between v_1 and v_2 is very small $\theta \approx 0°$

Now with equation (i),

$$\phi = 90° - \frac{0}{2} = 90°$$

588. If the radius of the circular path and frequency of revolution of particle of mass 'm' are doubled then the change in its kinetic energy will be (E_i and E_f are the initial and final kinetic energies of the particle respectively)

(a) $8E_i$ (b) $15E_i$

(c) $12E_i$ (d) $16E_i$

MHT-CET 2019

Ans. (b) : Initial kinetic energy of body,

$$E_i = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{2\pi r_1}{T_1}\right)^2 \quad \left(\because \ v = \frac{2\pi r}{T}\right)$$

So, $E_i = 2m\pi^2 r_1^2 f_1^2 \ldots\ldots$ (i)

Where, f_1 = Frequency of revolution

r_1 = Radius of circular path

Now, $r_2 = 2r_1$, and $f_2 = 2f_1$

So, $E_f = 2\pi^2 m r_2^2 \cdot f_2^2$

$$E_f = 2\pi^2 m (2r_1)^2 (2f_1)^2$$

$$E_f = 32\pi^2 m r_1^2 f_1^2$$

$$E_f = 16 \cdot 2\pi^2 m r_1^2 f_1^2$$

from eqn (i)

$$E_f = 16E_i$$

Now, change in kinetic energy,

$$\Delta E = E_f - E_i = 16E_i - E_i = 15E_i$$

589. A body of mass 'm' is performing a U.C.M. in a circle of radius 'r' with speed 'v'. The work done by the centripetal force in moving it through $\left(\frac{2}{3}\right)$ rd of the circular path is

(a) $mv^2\pi r$ (b) $\frac{2\pi mv^2 r}{3}$

(c) zero (d) $\frac{2mv^2\pi}{3}$

MHT-CET 2019

Ans. (c) : A body which is performing uniform circular motion, the centripetal force acts always in perpendicular direction to its velocity and work done by centripetal force is always zero.

i.e. $\Rightarrow WD = Fd\cos\theta$

$\Rightarrow WD = Fd\cos 90$

$\Rightarrow WD = 0$

Through, the work done by the centripetal force in moving it through $\left(\frac{2}{3}\right)^{rd}$ of the circular path is zero.

590. A wheel complete 2000 revolutions to cover the distance of 9.42 km. The diameter of this wheel is ($\pi = 3.14$)

(a) 1 cm (b) 1 m

(c) 1.5 cm (d) 1.5 m

MHT-CET 2019

Ans. (d): Given, distance (D) = 9.42 km = 9420 m

$\because$ Distance (D) = 2000 × (2πr)

Wheel makes 2000 revolutions, it is multiplied by the circumference of the circle of the distance cover by wheel.

$D = 2000 \times (\pi d) \quad (\because d = 2r)$

$9420 = 2000 \times (\pi d)$

$$d = \frac{9420\text{m}}{2000 \times \pi} = 1.499 = 1.5\text{m}$$

591. Two stones of masses 1m and 3m are whirled in horizontal circles, the heavier one in radius $\left(\frac{r}{3}\right)$ and lighter one in radius 'r'. The tangential speed of lighter stone is 'n' times that of the value of heavier stone, when they experience same centripetal force. The value of n is

(a) 4 (b) 1

(c) 2 (d) 3

MHT-CET 2019

Ans. (d) : Given, $r_1 = r$, $r_2 = \frac{r}{3}$, $m_1 = m$, $m_2 = 3m$

$v_2 = v$, $v_1 = nv$

Then, centripetal force is –

$$\frac{m_1 v_1^2}{r_1} = \frac{m_2 v_2^2}{r_2}$$

$$\frac{m(nv)^2}{r} = \frac{3mv^2}{\frac{r}{3}}$$

$n^2 = 9 \Rightarrow n = 3$

592. A ball of mass 0.25 kg attached to the end of a string of length 1.96 m is moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which ball can be moved?

(a) 14 ms^{-1} (b) 3 ms^{-1}

(c) 3.92 ms^{-1} (d) 5 ms^{-1}

MHT-CET 2011

@apna_pdf

Ans. (a): Given that, mass (m) = 0.25kg, radius (r) = 1.96m, tension (T) = 25N

Centrifugal force (F) = $\frac{mv^2}{r}$

Then, $T = \frac{mv^2}{r}$

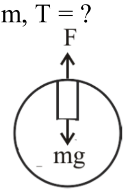
$$25 = \frac{0.25 \times v^2}{1.96} \Rightarrow v = 14\text{m/s}$$

593. A cane filled with water is revolved in a vertical circle of radius 4 m and the water does not fall down. The time period for a revolution is about

(a) 2 s
(b) 4 s
(c) 8 s
(d) 10 s

UPSEE-2014
JCECE-2010

Ans. (b): Given, r = 4m, T = ?



Let mass of water = m
Centrifugal force (F) = $m\omega^2 r$
Weight of water = mg
At highest point, mg = F

$$mg = m\omega^2 r$$

$$g = \frac{4\pi^2}{T^2} r \qquad \left(\because \omega = \frac{2\pi}{T}\right)$$

$$T^2 = \frac{4\pi^2 r}{g}$$

$$T = 2\pi\sqrt{\frac{r}{g}} = 2\pi\sqrt{\frac{4}{9.8}}$$

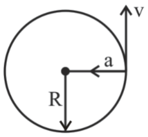
$$T = 4.01 \text{ sec} \approx 4 \text{ sec}$$

594. In uniform circular motion, the centripetal acceleration is

(a) towards the centre of the circular path and perpendicular to the instantaneous velocity
(b) a constant acceleration
(c) away from the centre of the circular path and perpendicular to the instantaneous velocity
(d) a variable acceleration making 45º with the instantaneous velocity
(e) A variable acceleration, parallel to the instantaneous velocity

Kerala CEE - 2016

Ans. (a) :



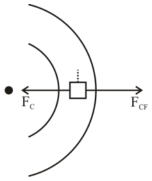
Centripetal acceleration generates a force due to which circular motion happens and its direction is always towards the centre of the circle and it is perpendicular to velocity because the direction of velocity is tangential to the circle. So it will always perpendicular to the instantaneous velocity.

595. A cyclist bends while taking turn in order to

(a) reduce friction
(b) provide required centripetal force
(c) reduce apparent weight
(d) reduce speed
(e) sit comfortably

Kerala CEE- 2014

Ans. (b) :



When the velocity is high, the centripetal force provided by friction is not enough and the cyclist has to bend. The normal force acting on the cyclist also has horizontal component which provides additional centripetal force.

596. A particle tied to a string describes a vertical circular motion of radius r continually. If it has a velocity $\sqrt{3gr}$ at the highest point, then the ratio of the respective tensions in the string holding it at the highest and lowest points is

(a) 4 : 3
(b) 5 : 4
(c) 1 : 4
(d) 3 : 2
(e) 1 : 2

Kerala CEE- 2013
MHT CET-2019

Ans. (c) : Given that,
Radius (r) = r
Velocity at highest point $(v) = \sqrt{3gr} = v_H$
Tension at highest point (T_H),

$$T_H = \frac{mv^2}{r} - mg$$

$$T_H = \frac{m\left(\sqrt{3gr}\right)^2}{r} - mg$$

$$T_H = \frac{m \times 3gr}{r} - mg$$

$$T_H = 2mg$$

Tension at lowest point (T_L),

$$T_L = \frac{mv^2}{r} + mg \qquad \ldots\ldots\ldots(i)$$

Velocity at lowest point (v_L),

So, $v_L^2 = v_H^2 + 2gs$

Here, $v_L^2 = 3gr + 2g \times 2r \qquad (\because s = 2r)$

$$v_L^2 = 7gr$$

From equation (i) we have

So, $T_L = 7mg + mg = 8mg$

Hence, $\frac{T_H}{T_L} = \frac{2mg}{8mg}$

$$\frac{T_H}{T_L} = \frac{1}{4}$$

@apna_pdf

597. A particle of mass m is moving in a horizontal circle of radius r, under a centripetal force $F = \frac{k}{r^2}$, where k is a constant.

(a) The potential energy of the particle is zero

(b) The potential energy of the particle is $\frac{k}{r}$

(c) The total energy of the particle is $-\frac{k}{2r}$

(d) The kinetic energy of the particle is $-\frac{k}{r}$

(e) The potential energy of the particle is $-\frac{k}{2r}$

Kerala CEE - 2011

Ans. (c) : Given that, radius of circle = r

Centripetal force (F) $= \frac{k}{r^2}$

We know that, centripetal force (F) $= \frac{mv^2}{r}$.

$$\frac{mv^2}{r} = \frac{k}{r^2} \Rightarrow mv^2 = \frac{k}{r}$$

$$\therefore \quad \text{K.E of particle} = \frac{1}{2}mv^2 = \frac{k}{2r}$$

The force acting on a particle is conservative in nature hence we can find potential energy (U) of the particle

$$F = -\frac{dU}{dr}$$

$$U = -\int_{\infty}^{r} F dr$$

$$U = -\int_{\infty}^{r}\left(\frac{-k}{r^2}\right)dr$$

$$U = -k\int_{\infty}^{r} r^{-2}dr = \frac{-k}{r}$$

$$\therefore \ \text{Total energy} = \text{K.E} + U = \frac{k}{2r} - \frac{k}{r} = \frac{k-2k}{2r} = \frac{-k}{2r}$$

598. A bridge is in the form of a semi-circle of radius 40 m . The greatest speed with which a motor cycle can cross the bridge without leaving the ground at the highest point is (g = 10 ms^{-2})
(Frictional force is negligibly small)

(a) 40 ms^{-1} (b) 20 ms^{-1}

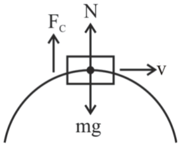
(c) 30 ms^{-1} (d) 15 ms^{-1}

(e) 25 ms^{-1}

Kerala CEE - 2011

Ans. (b) : Given that, $r = 40m$, $g = 10m/s^2$

F_C = centrifugal force



Force equation at highest point-

$$N + F_C = mg$$

$$N + \frac{mv^2}{r} = mg$$

To achieve greatest speed, without leaving the ground at highest point - N = 0

$$\frac{mv^2}{r} = mg$$

$$v^2 = rg = 40 \times 10 = 400$$

$$v = \sqrt{400}$$

$$v = 20 \text{ m/s}$$

599. A stone of mass 2 kg is tied to a string of length 0.5 m. If the breaking tension of the string is 900 N, then the maximum angular velocity, the stone can have in uniform circular motion is

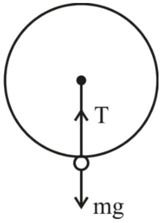
(a) 30 rad s^{-1} (b) 20 rad s^{-1}

(c) 10 rad s^{-1} (d) 25 rad s^{-1}

(e) 40 rad s^{-1}

Kerala CEE - 2010

Ans. (a) : Given that, mass (m) = 2kg, length (*l*) = r = 0.5m, tension of the string (T) = 900N



Centripetal force (F) $= \frac{mv^2}{r}$

Angular force (F) = T = $mr\omega^2$

$$900 = 2 \times 0.5 \times \omega^2$$

$$900 = 1 \times \omega^2$$

$$\omega = \sqrt{900} = 30\text{rad/sec}$$

600. A motor car is moving with a speed of 20 ms^{-1} on a circular track of radius 100 m. If its speed is increasing at the rate of 3 ms^{-2}, its resultant acceleration is

(a) 3 ms^{-2} (b) 5 ms^{-2}

(c) 2.5 ms^{-2} (d) 3.5 ms^{-2}

(e) 4 ms^{-2}

Kerala CEE - 2009

Ans. (b) : Given that, speed of car (v) = 20 m/s, radius of circular track (r) = 100m, $a_t = 3m/s^2$

Centripetal acceleration $(a_C) = \frac{v^2}{r}$

$$a_C = \frac{20 \times 20}{100} = \frac{400}{100} = 4m/s^2$$

So, resultant acceleration $(a_R) = \sqrt{a_C^2 + a_t^2}$

$$a_R = \sqrt{(4)^2 + (3)^2} \Rightarrow a_R = \sqrt{16+9}$$

$$a_R = \sqrt{25} = 5 \text{ m/s}^2$$

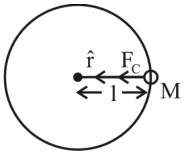
@apna_pdf

601. A stone of mass m tied to a string of length *l* is rotating along a circular path with constant speed v. The torque on the stone is:

(a) m*l*/v
(b) $\frac{mv}{l}$
(c) $\frac{mv^2}{l}$
(d) $mv^2 l$
(e) zero

Kerala CEE 2006

Ans. (e) :



If the body is moving within a circular motion, there will be a centrifugal force working along the center of the path. So, r and F_c working on the same axis hence, the net torques are zero.

$\vec{T} = \vec{r} \times \vec{F} = rF\sin\theta = rF\sin 0°$
$T = 0$

602. An athlete throws a discus from rest to a final angular velocity of 15 rad/s in 0.270 s before releasing it. During acceleration, discus moves a circular arc of radius 0.810 m. Acceleration of discus before it is released is .... ms^{-2}.

(a) 45
(b) 182
(c) 187
(d) 192
(e) 205

Kerala CEE 2004

Ans. (a) : Given that, angular velocity (ω_0)= 0 (rest), angular velocity (ω) = 15 rad/sec, time (t) = 0.270 sec, radius (r) = 0.810 m

We know, $\omega = \omega_0 + \alpha t$

$\omega = 0 + \alpha t \qquad (\because \omega_0 = 0)$

$\alpha = \frac{\omega}{t}$

$\alpha = \frac{15}{0.270}$ red/s²

We know, acceleration $(a) = r\alpha$

$a = 0.81 \times \frac{15}{0.270}$

$a = 45 m/s^2$

603. A wheel of radius 2 m rolls on the ground with a uniform velocity 4 m/s. The relative acceleration of the top most point of the wheel with respect to the bottom most point of the wheel is

(a) 8 m/s²
(b) 16 m/s²
(c) 4 m/s²
(d) 32 m/s²

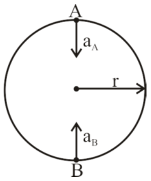
UPSEE - 2018

Ans. (b) : Given that, radius of wheel (r) = 2m

Velocity (v) = 4 m/s

Acceleration of the wheel in circular motion $(a) = \frac{v^2}{r}$

$a = \frac{(4)^2}{2} = \frac{16}{2} = 8 \text{ m/s}^2$



∴ Relative acceleration of top most point of the wheel with respect to bottom most point of the wheel

$a_r = a_B - a_A$
$= 8-(-8) = 8 + 8 = 16 \text{ m/s}^2$

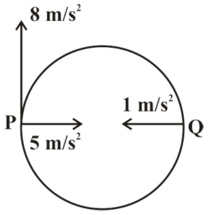
604. Two particles P and Q are moving on a circle. At a certain instant of time both the particles are diametrically opposite and P has tangential acceleration 8 m/s² and centripetal acceleration 5 m/s² whereas Q has only centripetal acceleration of 1 m/s². At that instant acceleration (in m/s²) of P with respect to Q is

(a) 14
(b) $\sqrt{80}$
(c) 10
(d) 12

UPSEE - 2017

Ans. (c) : Given,

Tangential acceleration of (P) = 8 m/s²
Centripetal of acceleration = 5 m/s²
Centripetal acceleration of (Q) = 1 m/s²
Instant acceleration of P = ?



$$\because \quad \vec{a}_{PQ} = \vec{a}_P - \vec{a}_Q$$

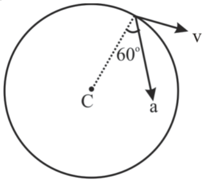
$$\vec{a}_{PQ} = \left(+5\hat{i} + 8\hat{j}\right) - \left(-1\hat{i}\right)$$

$$\vec{a}_{PQ} = 6\hat{i} + 8\hat{j}$$

$$|\vec{a}_{PQ}| = \sqrt{(6)^2 + (8)^2}$$

$$= \sqrt{36+64} = \sqrt{100} = 10 \text{ m/s}^2$$

605. Figure shows the total acceleration a = 32 m/s² of a moving particle moving clockwise in a circle of radius R = 1 m. What are the centripetal acceleration a and speed v of the particle at given instant?

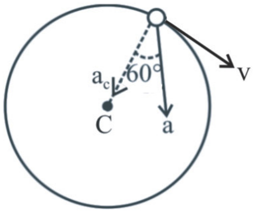


(a) $16\sqrt{3}\,m/s^2, 4\sqrt{3}\,m/s$
(b) $16\sqrt{3}\,m/s^2, 4\,m/s$
(c) $16\,m/s^2, 16\,m/s$
(d) $16\,m/s^2, 4\,m/s$

UPSEE - 2016

@apna_pdf

Ans. (d) : Given that, total acceleration $(a_T) = 32\ m/s^2$, radius $(R) = 1m$



From the figure, centripetal acceleration

$$a_c = a_T \cos\theta$$

$$a_c = 32 \cos 60°$$

$$a_c = 32 \times \frac{1}{2} = 16 m/s^2$$

Also, we know that,

$$a_c = \frac{v^2}{R}$$

$$v^2 = a_c R$$

$$v = \sqrt{a_c R} = \sqrt{16 \times 1} = 4 m/s$$

606. A stone of mass m is tied to a string and is moved in a vertical circle of radius 'r' making 'n' revolution per minute. The total tension in the string when the stone is at its lowest point is

(a) mg

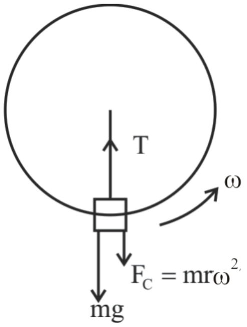
(b) $m(g + \pi n r^2)$

(c) $m(g + \pi n r)$

(d) $m\{g + (\pi^2 n^2 r)/900\}$

UPSEE - 2013

Ans. (d) :



We know, $T = F_C + mg$

$$T = mr\omega^2 + mg \quad ......(i)$$

$$T = mr\left(\frac{2\pi n}{60}\right)^2 + mg \qquad \left[\because \omega = \frac{2\pi n}{60}\right]$$

$$T = mr \times \frac{4\pi^2 n^2}{3600} + mg$$

$$T = mr \times \left(\frac{\pi^2 n^2}{900}\right) + mg$$

$$T = m\left(g + \frac{\pi^2 n^2 r}{900}\right)$$

607. A particle is moving in a vertical circle. The tension in the string when passing through two positions at angles 30° and 60° from vertical (lowest position) are T_1 and T_2 respectively

(a) $T_1 = T_2$

(b) $T_2 > T_1$

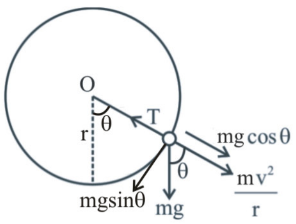
(c) $T_1 > T_2$

(d) tension in the string always remain the same

Manipal UGET-2019

UPSEE - 2013

Ans. (c) :



From figure, tension $(T) = \frac{mv^2}{r} + mg\cos\theta$

When, $\theta = 30°$

$$T_1 = \frac{mv^2}{r} + mg\cos 30° \qquad \left[\because \cos 30° = \frac{\sqrt{3}}{2}\right]$$

$$T_1 = \frac{mv^2}{r} + mg \times \frac{\sqrt{3}}{2} \qquad .....(i)$$

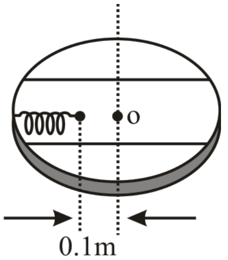
When, $\theta = 60°$

$$T_2 = \frac{mv^2}{r} + mg\cos 60° \qquad \left[\because \cos 60° = \frac{1}{2}\right]$$

$$T_2 = \frac{mv^2}{r} + mg \times \frac{1}{2} \qquad .....(ii)$$

From equation (i) and (ii) it is clear that $T_1 > T_2$.

608. A circular turn table of radius 0.5 m has a smooth groove as shown in figure. A ball of mass 90 g is placed inside the groove along with a spring of spring constant 10^2 N/cm. The ball is at a distance of 0.1 m from the centre when the turn table is at rest. O totating the turn table with a constant angular frequency of 10^2 sec^{-1}, the ball moves away from the centre by a distance nearly equal to



(a) 10^{-1}m

(b) 10^{-2}m

(c) 10^{-3}m

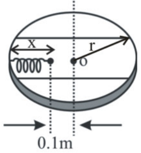
(d) 2×10^{-1}m

UPSEE - 2013

@apna_pdf

Ans. (b) : Given, $k = 10^2\ N\ cm^{-1} = 10^4\ N/m$

When the turn table rotates with angular speed (ω), the particle of mass (m) describes a circle of radius (r).



At equilibrium, balancing the centripetal force and the force experience due to spring

$$kx = mr\omega^2$$

$$100\times10^2 x = \frac{90}{1000}(0.1+x)10^4$$

$$x = \frac{9}{100}\times0.1+\frac{9x}{100}$$

$$x-\frac{9x}{100} = \frac{9}{1000}$$

$$\frac{91x}{100} = \frac{9}{1000}$$

$$x = \frac{9}{910}$$

$$x = 0.00989$$

$$x = 0.01$$

$$x = 10^{-2}\,m$$

609. Keeping the banking angle same, to increase the maximum speed with which a vehicle can travel on the curved road by 10%, the radius of curvature of the road has to be changed from 20 m to

(a) 16 m (b) 18 m
(c) 24.2 m (d) 30.5 m

UPSEE - 2010

Ans. (c) : Let m is the mass of the vehicle, g is the acceleration due to gravity, v is the velocity of the vehicle and r is the radius of the circle in which the vehicle is moving θ is the banking angle.

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan\theta = \frac{v^2}{20g} \quad \text{....(i)} \quad [\because r = 20m]$$

If $v' = v + 10\%\ v$

$$v' = v + \frac{10}{100}v$$

$$v' = v + 0.1v$$

$$v' = 1.1v$$

Then,

$$\tan\theta = \frac{v'^2}{r'g} = \frac{(1.1v)^2}{r'g} \quad \text{....(ii)}$$

Equating equation (i) and (ii), we get –

$$\frac{1}{20} = \frac{1.21}{r'}$$

$$r' = 20 \times 1.21$$

$$r' = 24.2\ m$$

610. The centripetal acceleration of a body moving in a circle of radius 100 m with a time period of 2s will be

(a) $98.5\ ms^{-2}$ (b) $198.5\ ms^{-2}$
(c) $49.29\ ms^{-2}$ (d) $985.9\ ms^{-2}$

UPSEE - 2009

Ans. (d) : Given that, r = 100m, t = 2 sec

Centripetal acceleration

$$a_c = \omega^2 r = \left(\frac{2\pi}{T}\right)^2 r$$

$$= \frac{4\pi^2}{2^2}\times100 = 986.96\ m/s^2 \approx 985.9\ m/s^2$$

611. Two cars A and B are going around concentric circular paths of radii R_A and R_B. If the two cars complete the circular paths in the same time, then the ratio of angular speed of A and B is

(a) 1 : 1 (b) $R_A : R_B$
(c) $R_B : R_A$ (d) 1 : 2

AP EAMCET (22.09.2020) Shift-I

Ans. (a) :

Angular speed of A –

$$\omega_A = \frac{2\pi}{T_A} \quad \text{.........(i)}$$

Angular speed of B -

$$\omega_B = \frac{2\pi}{T_B} \quad \text{......... (ii)}$$

Dividing eq^n. (i) by equation (ii), we get –

$$\frac{\omega_A}{\omega_B} = \frac{T_B}{T_A}$$

Since, $T_A = T_B$

$$\therefore \quad \frac{\omega_A}{\omega_B} = \frac{T_A}{T_A} \Rightarrow \frac{\omega_A}{\omega_B} = \frac{1}{1}$$

$$\therefore \quad \omega_A : \omega_B = 1:1$$

612. A stone of mass 2 kg tied to a light inextensible string of length $\frac{5}{3}$m is whirling in a circular path in a vertical plane. If the ratio of the maximum tension to the minimum tension in the string is 4, then the speed of the stone at the highest point of the circle is ($g = 10\ ms^{-2}$)

(a) $20\ ms^{-1}$ (b) $10\sqrt{3}\ ms^{-1}$
(c) $\sqrt{50}\ ms^{-1}$ (d) $10\ ms^{-1}$

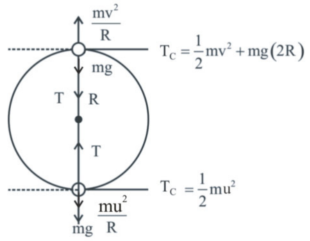
AP EAMCET (20.04.2019) Shift-1

Ans. (c) : Given that,

$$\text{Radius }(R) = \frac{5}{3}m$$

Mass (m) = 2kg

@apna_pdf



$$T_{max} = mg + \frac{mu^2}{R} \qquad ....(i)$$

Tension is minimum at top

$$T_{min} = \frac{mv^2}{R} - mg \_\_\_(ii)$$

Dividing equation (i) and (ii), we get –

$$\frac{T_{max}}{T_{min}} = \frac{m\left(g + \frac{u^2}{R}\right)}{m\left(\frac{v^2}{R} - g\right)} = 4$$

$$\frac{g + \frac{u^2}{R}}{\frac{v^2}{R} - g} = 4$$

$$4v^2 - 4Rg = Rg + u^2$$

$$4v^2 = 5Rg + u^2 \qquad ....\ (iii)$$

Total energy comparing-

So, $$\frac{1}{2}mv^2 + mg(2R) = \frac{1}{2}mu^2$$

$$u^2 = v^2 + 4gR$$

Putting the value of u^2 in equation (iii), we get –

$$4v^2 = 5gR + v^2 + 4gR$$

$$3v^2 = 9gR$$

$$v^2 = 3gR$$

$$v = \sqrt{3gR}$$

$$v = \sqrt{3 \times 10 \times \frac{5}{3}} \qquad \because R = \frac{5}{3}, g = 10$$

$$v = \sqrt{50}\ m/s$$

613. **Assertion (A) :** The speed of a body in uniform circular motion is constant.

Reason (R) : In uniform circular motion, the acceleration of the body is constant.

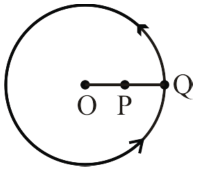
(a) Both (A) and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(c) (A) is true but (R) is false.
(d) (A) is false but (R) is true.

AP EAMCET (20.04.2019) Shift-1

Ans. (c) : • Body moves with constant speed, it's magnitude of velocity is constant.

• Acceleration is a vector quantity therefore its direction is changing it means acceleration is also changing.

614. Two spheres P and Q, each of mass 200 g are attached to a string of length one metre as shown in the figure. The string and the spheres are then whirled in a horizontal circle about O at a constant angular speed. The ratio of the tension in the string between P and Q to that of between P and O is (P is at mid-point of the line joining O and Q)

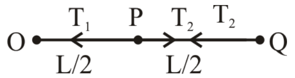


(a) $\frac{1}{2}$ (b) $\frac{2}{3}$

(c) $\frac{3}{2}$ (d) $\frac{2}{1}$

AP EAMCET (22.04.2018) Shift-1

Ans. (b) :



From figure, $OP = PQ = \frac{OQ}{2} = \frac{L}{2}$

For mass of P, $T_1 - T_2 = m\omega^2\left(\frac{L}{2}\right)$

For mass of Q, $T_2 = m\omega^2 L$ ....(i)

$$T_1 = m\omega^2\frac{L}{2} + m\omega^2 L$$

$$= \frac{3}{2}\omega^2 mL \qquad ....(ii)$$

Dividing equation (ii) by equation (i), we get–

$$\therefore \quad \frac{T_2}{T_1} = \frac{m\omega^2 L}{\frac{3}{2}m\omega^2 L} = \frac{2}{3}$$

615. A particle is moving in a circular path. The acceleration and momentum vectors at an instant of time are $\vec{a} = 2\hat{i} + 3\hat{j}\ m/s^2$ and $\vec{p} = 6\hat{i} - 4\hat{j}$ kgm/s. Then the motion of the particle is

(a) uniform circular motion
(b) circular motion with tangential acceleration
(c) circular motion with tangential retardation
(d) we cannot say anything about a and p only

BITSAT-2005

Ans. (a) : We consider the dot product of $\vec{a}$ and $\vec{p}$,

$$\vec{a} \cdot \vec{p} = (2\hat{i} + 3\hat{j})(6\hat{i} - 4\hat{j})$$

$$= (2 \times 6) - (3 \times 4) = 12 - 12 = 0$$

$\therefore$ $\vec{a}$ is perpendicular to $\vec{p}$.

$\therefore$ Motion is uniform circular motion.

616. A body is travelling in a circle at a constant speed. It

(a) has a constant velocity
(b) is not accelerated

@apna_pdf

(c) has an inward radial acceleration
(d) has an outward radial acceleration

BITSAT-2010

Ans. (c): A body travelling a circle at a constant speed. Therefore, the tangential component of the acceleration a_T is zero and it has only the centripetal acceleration a_c which is directed towards the centre. So, it has an inward acceleration.

In inward radial acceleration, magnitude of velocity is constant but direction is changing continuously

617. The velocity and acceleration vectors of a particle undergoing circular motion are $\vec{v} = 2\hat{i}$ m/s and $\vec{a} = 2\hat{i} + 4\hat{j}$ m/s^2 respectively at an instant of time. The radius of the circle is

(a) 1m	(b) 2m
(c) 3m	(d) 4m

BITSAT-2013

Ans. (a) : Given that,

$$\vec{v} = 2\hat{i}\,\text{m/s}, \quad v_x = 2, v_y = 0$$

$$\vec{a} = \left(2\hat{i} + 4\hat{j}\right)\text{m/s}^2, \quad a_x = 2, \quad a_y = 4$$

Tangential velocity in circular motion, the centripetal acceleration is toward centre.

Radial acceleration in a centripetal acceleration is

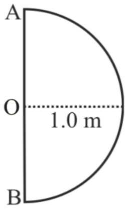
$$a_r = \frac{v^2}{r} \Rightarrow a_y = \frac{v_x^2}{r}$$

$$4 = \frac{2^2}{r} \quad (\text{Since, } a_y = 4 \text{ and } \vec{v} = 2\ )$$

$$r = 1\text{m}$$

Hence, the radius of the circle is 1m.

618. In 1.0 s, a particle goes from A to B moving in a semicircle of 1.0 m radius (as shown in the figure)

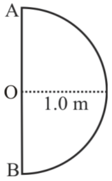


The magnitude of the average velocity is

(a) 3.14 m/s	(b) 2.0 m/s
(c) 1.0 m/s	(d) zero

CG PET- 2017

Ans. (b) : Given that, Time (t) = 1.0 sec, r = 1.0 m



Total displacement of the particle from A to B time taken, (t) = 1sec

Then,

$$\text{Average velocity} = \frac{\text{displacement}}{\text{Time}} = \frac{s}{t} = \frac{2}{1} = 2\,\text{m/s}$$

619. The speed of revolution of a particle going around a circle is doubled and its angular speed is halved. That happens to the centripetal acceleration?

(a) Remains unchanged	(b) Halved
(c) Doubled	(d) Becomes four times

CG PET- 2010

Ans. (a) : Centripetal acceleration $(a_C) = r\omega^2 = v\omega$

Now speed is doubled but the angular speed is halved

then, $v' = 2v$ and $\omega' = \dfrac{\omega}{2}$

$\therefore$ Now centripetal acceleration

$$a'_C = v'\omega' = (2v) \times \frac{\omega}{2} = v\omega = a_C$$

If v is doubled and ω is halved then the centripetal acceleration remains unchanged.

620. A car is circulating on the path of radius r and at any time its velocity is v and rate of increase of velocity is a .The resultant acceleration of the car will be

(a) $\sqrt{\dfrac{v^2}{a^2} + r^2}$	(b) $\sqrt{\dfrac{v^2}{r} + a}$
(c) $\sqrt{\dfrac{v^4}{r^2} + a^2}$	(d) $\left(\dfrac{v^2}{r} + a\right)$

CG PET- 2009

Ans. (c) : Given,

Radius of car = r

Instant velocity = v m/s

Increase in velocity = tangential acceleration

Tangential acceleration (a_t) = a m/s^2

Now, we know that when particle circular motion radial acceleration acts toward the centre.

$$\therefore \text{ Radial acceleration } (a_r) = \frac{v^2}{r}$$

$$\text{Resultant acceleration, } (a_R) = \sqrt{a_r^2 + a_t^2}$$

$$\text{So,} \quad a_R = \sqrt{\left(\frac{v^2}{r}\right)^2 + a^2}$$

$$\boxed{a_R = \sqrt{\frac{v^4}{r^2} + a^2}}$$

621. A particle moves with constant speed v along a circular path of radius r and completes the circle in time T. The acceleration of the particle is

(a) $\dfrac{2\pi v}{T}$	(b) $\dfrac{2\pi r}{T}$
(c) $\dfrac{2\pi r^2}{T}$	(d) $\dfrac{2\pi v^2}{T}$

Manipal UGET-2019

@apna_pdf

Ans. (a) : Given that,

Speed of particle = v

Time taken = T

Radius of circle = r

We know that,

$$\omega = \frac{2\pi}{T}\text{rad/sec}$$

$$a_c = \omega^2 r$$

Putting the value of ω

$$a_c = \left(\frac{2\pi}{T}\right)^2 \times r$$

$$a_c = \frac{4\pi^2}{T^2} \times r$$

$$a_c = \frac{2\pi}{T} \times \frac{2\pi r}{T}$$

Putting the value of v [∵ v = 2πr/T]

So, $a_c = \dfrac{2\pi v}{T}$

622. The kinetic energy k of a particle moving along a circle of radius R depends on the distance covered. It is given as KE = as^2, where a is a constant. The force acting on the particle is

(a) $2a\dfrac{s^2}{R}$ (b) $2as\left(1+\dfrac{s^2}{R^2}\right)$

(c) 2 as (d) $2a\dfrac{R^2}{s}$

Manipal UGET-2014

Ans. (b): Given, KE = as^2 (where a is constant)

We know that, $KE = \dfrac{1}{2}mv^2$

$$\frac{1}{2}mv^2 = as^2$$

$$mv^2 = 2as^2$$

$$v^2 = \frac{2as^2}{m}$$

$$v = \sqrt{\frac{2as^2}{m}} = s\sqrt{\frac{2a}{m}} \qquad .....(i)$$

Differential equation (i) w.r.t. s,

$$\frac{dv}{ds} = \sqrt{\frac{2a}{m}} \qquad .....(ii)$$

We know,

$$a_r = \frac{v^2}{R} \Rightarrow a_r = \frac{2s^2a}{mR}$$

For tangential acceleration

$$a_t = \frac{dv}{dt} = \frac{dv}{ds}.\frac{ds}{dt} = v\frac{dv}{ds}$$

From equation (i) & (ii), we get–

$$a_t = \left[s\sqrt{\frac{2a}{m}}\right]\left[\sqrt{\frac{2a}{m}}\right]$$

$$a_t = \frac{2as}{m} \qquad ....(iii)$$

So, $a = \sqrt{a_R^2 + a_t^2}$

$$= \sqrt{\left(\frac{2as^2}{mR}\right)^2 + \left(\frac{2as}{m}\right)^2}$$

$$a = \frac{2as}{m}\sqrt{1+\left(\frac{s}{R}\right)^2}$$

We know that,

Force (F) = ma

$$F = m \times \frac{2as}{m}\sqrt{1+\left(\frac{s}{R}\right)^2}$$

$$F = 2as\sqrt{1+\left(\frac{s}{R}\right)^2}$$

623. A wet open umbrella is held vertical and it whirled about the handle at a uniform rate of 21 revolutions in 44s. If the rim of the umbrella is circle of 1 m in diameter and the height of the rim above the flour is 4.9 m, the locus of the drop is a circle of radius

(a) $\sqrt{2.5}$m (b) 1 m

(c) 3 m (d) 1.5 m

Manipal UGET-2013

Ans. (a) : Given, h = 4.9 m, D = 1 m, r = 0.5 m

$$\text{Time } (T) = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times 4.9}{9.8}} = 1\text{sec}$$

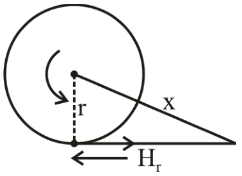
$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{21\times 2\pi}{44} = 3\,\text{rad/sec}$$

Tangential speed (v_t) = rω

= 0.5 × 3 = 1.5 m/s

Horizontal range (H_r) = v_t × T

= 1.5 × 1 = 1.5 m



Rain drop

$$x = \sqrt{r^2 + (H_r)^2} = \sqrt{(0.5)^2 + (1.5)^2}$$

$$= \sqrt{0.25 + 2.25} = \sqrt{2.5}\,\text{m}$$

624. A particle is moving along a circular path of radius 5 m with a uniform speed 5ms^{-1}. What will be the average acceleration when the particle completes half revolution?

(a) Zero (b) 10 ms^{-2}

(c) $10\pi\,\text{ms}^{-2}$ (d) $\dfrac{10}{\pi}\text{ms}^{-2}$

Manipal UGET-2012

JCECE-2003

@apna_pdf

Ans. (d) : The change in velocity, when the particle completes half the revolution is given by

$$\Delta v = [5 - (-5)]\text{ m/s} = 10\text{ m/s}$$

Time taken to complete half revolution is given by

$$t = \frac{\pi r}{v} = \frac{\pi \times 5}{5} = \pi\text{ s}$$

Average acceleration $= \frac{\Delta v}{t} = \frac{10}{\pi}\text{ m/s}^2$

625. Two cars A and B move along a concentric circular path of radius r_A and r_B with velocities v_A and v_B maintaining constant distance, then $\frac{v_A}{v_B}$ is equal to

(a) $\frac{r_B}{r_A}$ (b) $\frac{r_A}{r_B}$

(c) $\frac{r_A^2}{r_B^2}$ (d) $\frac{r_B^2}{r_A^2}$

Manipal UGET-2010

Ans. (b) : Let the linear velocity of buses A and B be v_A and v_B and their angular velocity be ω_A and ω_B respectively.

Given that, time period are same for both buses

$$T_A = T_B$$

We know that, Time period $T = \frac{2\pi}{\omega}$

$$\frac{2\pi}{\omega_A} = \frac{2\pi}{\omega_B} \qquad (T_A = T_B)$$

$$\omega_A = \omega_B$$

$\omega = \frac{v}{r}$ where v = linear velocity and r = radius of circle.

So, $\frac{v_A}{r_A} = \frac{v_B}{r_B}$

The ratio of velocity (linear) of buses is

$$\boxed{\frac{v_A}{v_B} = \frac{r_A}{r_B}}$$

626. A ball moves one-fourth $\left(\frac{1^{th}}{4}\right)$ of a circle of radius R in time T. Let v_1 and v_2 be the magnitudes of mean speed and mean velocity vector. The ratio $\frac{v_1}{v_2}$ will be

(a) $\frac{\pi}{2}$ (b) $\frac{3}{\pi}$

(c) $\frac{2}{\sqrt{3}\pi}$ (d) $\frac{\pi}{2\sqrt{2}}$

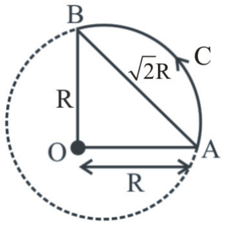
TS-EAMCET-04.05.2019, Shift-1
MHT CET-2019

Ans. (d) : Mean speed of a moving body is given by,

$$v_1 = \frac{\text{total distance}}{\text{total time taken}} \qquad \text{....(i)}$$

Mean velocity vector for a moving body.

$$v_2 = \frac{\text{total displacement}}{\text{total time taken}} \qquad \text{....(ii)}$$



From the figure,

ACB is the total distance $= \frac{2\pi R}{4}$

And AB is total displacement $= \sqrt{2}R$

A ball moving in a circular arc is shown in the figure below,

From equation (i)

$$v_1 = \frac{2\pi R}{4} \times \frac{1}{T} = \frac{\pi R}{2T}$$

From equation (ii)

$v_2 = \frac{\sqrt{2}R}{T}$ Then, $\frac{v_1}{v_2} = \frac{\pi}{2\sqrt{2}}$

627. A circular freeway entrance and exit are commonly banked to control a moving car at 14 m/s. To design similar ramp for 28 m/s one should

(a) increase the radius by factor 2
(b) increase the radius by factor 4
(c) decrease the radius by factor 4
(d) decrease the radius by factor 2

TS-EAMCET.11.09.2020, Shift-2

Ans. (b) : The equation for banking is

$$\tan\theta = \frac{v^2}{rg}$$

Where r is the radius and g is acceleration due to gravity

For design similar ramp tanθ remain constant

Then,

$$\frac{(14)^2}{r} = \frac{(28)^2}{r'}$$

So r' = 4r (increasing the radius by factor 4)

It means, radius increase by factor 4.

628. Consider a particle is moving with a minimum speed v at highest point of vertical circle of radius R. If the radius of the circle doubled the corresponding minimum speed will be

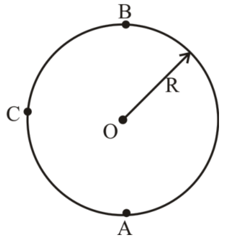
(a) v (b) $\frac{v}{\sqrt{2}}$

(c) $\sqrt{3}$ v (d) $\sqrt{2}$ v

TS-EAMCET-14.09.2020, Shift-1

@apna_pdf

Ans. (d) : Let a circle with radius (R) moving in a vertical plane.



There are three point on circle A,B and C which has minimum velocity as $\sqrt{5gR}, \sqrt{gR}$ and $\sqrt{3gR}$ respectively Then for highest point (i.e point B)

$$V \propto \sqrt{R}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{R_1}{R_2}} \qquad ....(i)$$

$R_1 = R$, $V_1 = V$ and $R_2 = 2R$

From equation (i)

$$\frac{V}{V_2} = \sqrt{\frac{R}{2R}} \Rightarrow V_2 = \sqrt{2}V$$

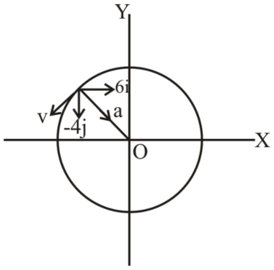
629. A point P is moving in uniform circular motion with radius 3m. Let at some instant the acceleration of the point is $a = \left(6\hat{i} - 4\hat{j}\right)$ m/s^2, the position vector is r and velocity vector is v. Choose the correct statement.

(a) v. a = 0 and r × a ≠ 0
(b) v. a ≠ 0 and r × a ≠ 0
(c) v. a = 0 and r × a = 0
(d) v. a ≠ 0 and r × a = 0

TS-EAMCET-10.09.2020, Shift-2

Ans. (c) : Given,

Acceleration, $a = 6\hat{i} - 4\hat{j}$



From the figure,

Acceleration a is perpendicular to velocity v

Then,

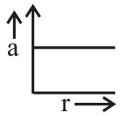
$$v.a = 0$$

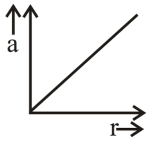
And position vector r is parallel to acceleration a

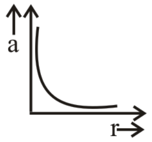
Then,

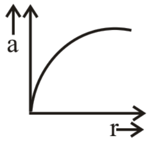
$$r \times a = 0$$

630. If a body moving in a circular path maintains constant speed of 10ms^{-1}, then which of the following correctly describes the relation between acceleration (a) and radius (r)?

(a)


(b)


(c)


(d)


TS-EAMCET-10.09.2020, Shift-1

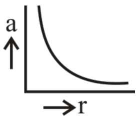
Ans. (c) : Tangential acceleration is independent of r

Centripetal acceleration $= \frac{v^2}{r}$

where, v is constant

then

$$a \propto \frac{1}{r}$$



Hence, graph between acceleration & radius is hyperbola.

631. Consider an object making uniform motion around a circle of radius 5 m with tangential velocity 2 ms^{-1}. The time it takes to complete 2 revolution and the magnitude of acceleration respectively are

(a) 0.2π s and 0.8 ms^{-2}
(b) 0.5π s and 1 ms^{-2}
(c) 10π s and 0.8 ms^{-2}
(d) 5π s and 5 ms^{-2}

TS-EAMCET-04.05.2018, Shift-2

Ans. (c) : Given that, circle of radius = 5m

Tangential velocity (v) = 2 m/s

Here, 2 revolutions complete by object.

We know that,

$$v = \omega r = \frac{v}{r} = \omega$$

$$\omega = \frac{2}{5} \text{rad/s}$$

Also, $$\omega = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{2/5}$$

T= 5π sec for one revolution,

Object completes 2 revolutions in time.

Then, T = 2 × 5 × π = 10π sec

And acceleration, $a = \frac{v^2}{r} = \frac{(2)^2}{5} = 0.8\,\text{ms}^{-2}$

632. A particle moves in a circle with speed v varying with time as v (t) = 2t. The total acceleration of the particle after it completes 2 rounds of cycle is

(a) 16π
(b) $2\sqrt{1+64\pi^2}$
(c) $2\sqrt{1+49\pi^2}$
(d) 14π

TS-EAMCET-05.05.2018, Shift-1

@apna_pdf

Ans. (b) : Given,

$$v(t) = 2t$$

Total acceleration $(a_T) = \sqrt{a_t^2 + a_c^2}$

$$a_c = \frac{v^2}{r} = \frac{(2t)^2}{r} = \frac{4t^2}{r} \qquad \text{....(1)}$$

$$v = r\omega$$

$$\omega = \frac{v}{r} = \frac{2t}{r} \Rightarrow \omega = \frac{d\theta}{dt}$$

$$\theta = \int \frac{2t}{r} dt = \frac{2}{r}\frac{t^2}{2} = \frac{t^2}{r}$$

n = 2 round of cycle

$$4\pi = \frac{t^2}{r} \Rightarrow t^2 = 4\pi r \qquad \text{....(2)}$$

Centripetal acceleration $(a_c) = \frac{4t^2}{r} = \frac{4(4\pi r)}{r} = 16\pi$

$$a_t = \frac{dv}{dt} = \frac{d}{dt}(2t) = 2$$

$$a_T = \sqrt{{a_c}^2 + {a_t}^2} = \sqrt{(2)^2 + (16\pi)^2}$$

$$= \sqrt{4 + 256\pi^2}$$

$$= \sqrt{4(1 + 64\pi^2)} = 2\sqrt{1 + 64\pi^2}$$

633. A car turns a corner on a slippery road at a constant speed of 10 m/s. If the coefficient of friction is 0.5, the minimum radius of the arc in metre in which the car turns is

(a) 20 (b) 10

(c) 5 (d) 4

JCECE-2016

Ans. (a) : Given,

Velocity v = 10 m/s

friction, $\mu = 0.5$

radius of the arc r = ?

We know,

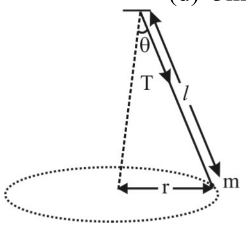
$$v = \sqrt{\mu g r}$$

$$r = \frac{v^2}{\mu g} = \frac{(10)^2}{0.5 \times 10} = \frac{100}{0.5 \times 10} = 20\,\text{m}$$

634. A string of length *l* fixed at one end carries a mass m at the other end. The string makes $\frac{2}{\pi}$ rev/s around the horizontal axis through the fixed end as shown in the figure, the tension in the string

(a) 16 m*l* (b) 6m*l*

(c) 5 m*l* (d) 3m*l*

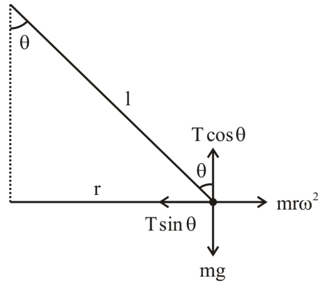


JCECE-2014

Ans. (a) : Given,

$$\omega = \frac{2}{\pi} \text{ rev/sec}$$

$$\omega = 2\pi n = 4$$



From figure, $r = l\sin\theta$

$\therefore \quad T\sin\theta = mr\omega^2$

$T\sin\theta = ml\sin\theta\omega^2$

$T = ml\omega^2 = ml(4)^2 = 16\,ml$

635. A body of mass 0.1 kg when rotated in a circular path of diameter 1.0 m on a frictionless horizontal plane by means of string, makes 10 revolutions in 31.4 seconds. The centripetal force acting on the body will be

(a) 0.2 N (b) 0.1 N

(c) 2 N (d) 1 N

JCECE-2013

Ans. (a) : Given,

m = 0.1 kg, diameter (d) = 1.0

radius (r) = $\frac{1.0}{2} = 0.5\,\text{m}$

Then, $\omega = \frac{N}{60} \times 2\pi\,\text{rad/s}$ ....(i)

In 31.4 sec make 10 revolution

Then, 1 second = $\frac{10}{31.4} \times$ revolution

1 minute = $\frac{10}{31.4} \times 60$ revolution

$N = \frac{600}{31.4}$ rpm

Now putting the value of N in equation (i)

$$\omega = \frac{600}{31.4 \times 60} \times 2\pi$$

$$\omega = 2 \text{ rad/sec}$$

Now we get the centripetal force

$F_c = mr\omega^2$

$= (0.1) \times (0.5) \times 2^2$

$= 0.2$ N

636. On a railway curve, the outside rail is laid higher than the inside one so that resultant force exerted on the wheels of the rail car by the tops of the rail will

(a) equilibrate the centripetal force

(b) be vertical

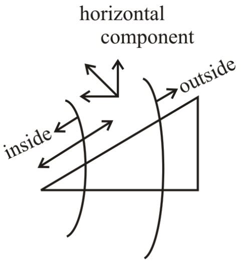
(c) be decreased

(d) have a horizontal inward component

JCECE-2012

@apna_pdf

Ans. (d):



From figure We can say that the top of the rail will have a horizontal inward component.

637. The centripetal acceleration of particle of mass m moving with a velocity v in a circular orbit of radius r is :

(a) v^2/r along the radius, towards the centre
(b) v^2/r along the radius, away from the centre
(c) mv^2/r along the radius, away the centre
(d) mv^2/r along the radius, towards the centre

JCECE-2005

Ans. (a) : We know, centripetal acceleration $\left(a_c\right)=\frac{v^2}{r}$

And act towards center.

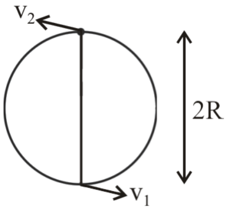
638. A body of mass 1 kg is rotating in a vertical circle of radius 1 m. What with is the difference in kinetic energy at the top and at the bottom of the circle? (Take g = 10 m/s^2)

(a) 50 J
(b) 30 J
(c) 20 J
(d) 10 J

JCECE-2004

Ans. (c) : Given that,

Mass = 1 kg
Radius = 1 m



As we know, kinetic energy = $\frac{1}{2}mv^2$

So, $\frac{1}{2}mv_1^2=\frac{1}{2}mv_2^2+mg(2R)$

$\frac{1}{2}mv_1^2-\frac{1}{2}mv_2^2=mg(2R)$

$\Delta K.E.=1\times10\times2\times1=20\text{ J}$

639. Two particles starting from a point on a circle of radius 4 m in horizontal plane move along the circle with constant speeds of 4 m s^{-1} and 6 m s^{-1} respectively in opposite directions. The particles will collide with each other after a time of

(a) 3.0 s
(b) 2.5 s
(c) 2.0 s
(d) 1.5 s

COMEDK 2016

Ans. (b): Given that,

Radius = 4 m, v_1 = 4 m/s, v_2 = 6 m/s

Relative speed of particle in opposite direction–

$v_{rel}=v_1+v_2$
$=4+6$
$=10$ m/s

Circumference of circle = $2\pi r$
$=2\times\pi\times4$

The particles will collide with each other after a time of

$$t=\frac{\text{Circumference of circle}}{\text{Relative speed between them}}$$

$$=\frac{2\pi\times4}{10}=2.5\text{ s}$$

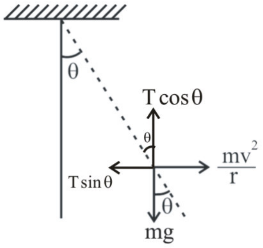
640. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s . A bob is suspended from the roof of the car by a light wire of length 1.0 m. The angle made by the wire with the vertical is

(a) $\frac{\pi}{3}$
(b) $\frac{\pi}{6}$
(c) $\frac{\pi}{4}$
(d) 0^o

COMEDK 2013

Ans. (c): Given that,

Radius = 10 m
Velocity = 10 m/s



From figure, on resolving tension we get

$T\cos\theta=mg$ ....(1)

$T\sin\theta=\frac{mv^2}{r}$ ...(2)

Dividing equation by (2) and (1) we get–

$$\tan\theta=\frac{v^2}{rg}=\frac{10\times10}{10\times10}=1$$

$$\theta=\tan^{-1}(1)=\frac{\pi}{4}$$

$$\boxed{\theta=\frac{\pi}{4}}$$

So, option (c) is correct.

641. Assertion: There is a stage when frictional force is not needed at all to provide the necessary centripetal force on a banked road.

Reason: On a banked road, due to its inclination the vehicle tends to remain inwards without any chances of skidding.

@apna_pdf

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2016

Ans. (c): When the car is driven at optimum speed. Then the normal reaction component is enough to provide the centripetal force.

642. Assertion: When a particle moves in a circle with a uniform speed, its velocity and acceleration both changes.
Reason: The centripetal acceleration in circular motion is dependent on angular velocity of the body.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2010

Ans. (b) : In uniform circular motion, the magnitude of velocity and acceleration remains same, but due to change in direction of motion, the direction of velocity and acceleration changes.

centripetal acceleration is given by $a_c = \omega^2 r$.

Hence, centripetal acceleration in circular motion is dependent on angular velocity of the body.

643. For a particle in a uniformly accelerated circular motion

(a) velocity is radial and acceleration has both radial and transverse components
(b) velocity is transverse and acceleration has both radial and transverse components
(c) velocity is radial and acceleration is transverse only
(d) velocity is traverse and acceleration is radial only

AIIMS-2011

Ans. (b): In case of uniformly accelerated circular motion, the velocity of particle is always tangential but its acceleration has two components radial component which acts towards the centre of motion and other is tangential component which is parallel to the direction of velocity.

644. At the uppermost point of a projectile, its velocity and acceleration are at an angle of

(a) 180° (b) 90°
(c) 60° (d) 45°

AIIMS-2002

Ans. (b) : At the upper most points of a projectile, the vertical component of the velocity of projection become zero while the horizontal component remain constant. And acceleration is always vertically downward. Therefore its velocity and acceleration are at an angle of 90^o.

645. An electron is moving in a circle of radius 2m with speed 4 m/s. Find the acceleration of the electron.

(a) 8 m/s^2 (b) 4 m/s^2
(c) 16 m/s^2 (d) 10 m/s^2

AIIMS-26.05.2019(E) Shift-2

Ans. (a) : Given that,

v = 4 m/s, r = 2 m

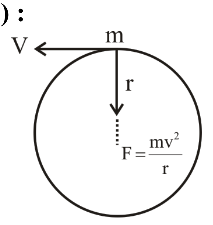
$$\text{Acceleration of electron} = \frac{v^2}{r} = \frac{(4)^2}{2} = \frac{16}{2} = 8\,m/s^2$$

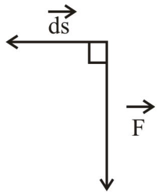
646. A body of mass m is moving in a circle of radius r with a constant speed v. If a force $\frac{mv^2}{r}$ is acting on the body towards the centre, then what will be the work done by this force in moving the body over half the circumference of the circle?

(a) Zero (b) $\frac{mv^2}{2}$
(c) $\frac{mv^2}{r} \times \pi r$ (d) $\frac{\pi r^2}{mv^2}$

BCECE-2012
JEECE-2006

Ans. (a) :





Work done = Force × displacement

$w = \vec{F}.\vec{ds}$

$= F.ds \cos 90^o = 0$

Since, the angle between direction of force and the direction of displacement is always 90° and $\cos 90^o = 0$

Then, work done is zero.

647. A bucket of water is being revolved in vertical circle of radius 1m. Minimum frequency required to prevent the water from getting down the path is ($g = 10\ m/s^2$)

(a) $\frac{2\pi}{\sqrt{10}}$ (b) $\frac{2\pi}{\sqrt{5}}$
(c) $\frac{\sqrt{10}}{2\pi}$ (d) $\frac{\sqrt{5}}{2\pi}$

BCECE-2011

@apna_pdf

Ans. (c) : We know that,
Centripetal force–

$$\frac{mv^2}{r} = mg$$

$$\frac{v^2}{r} = g$$

$$v^2 = rg$$

$$v = \sqrt{rg}$$

$$v = r.\omega = 2\pi nr \qquad \text{(Where n is the frequency)}$$

$$2\pi nr = \sqrt{rg}$$

$$n = \frac{\sqrt{rg}}{2\pi r} = \frac{\sqrt{1\times10}}{2\pi\times1} = \frac{\sqrt{10}}{2\pi}\text{Hz}$$

648. A weightless thread can bear tension upto 3.7 kg-wt. A stone of mass 500g is tied to it and revolved in a circular path of radius 4m in a vertical plane. If $g = 10ms^{-2}$, then the maximum angular velocity of the stone will be:

(a) 4 rad/s (b) 16 rad/s
(c) $\sqrt{21}$ rad/s (d) 2 rad/s

BCECE-2003

Ans. (a) : Given that,

$T_{max} = 3.7$ kg-wt
$m = 500$ gm $= 0.5$ kg
$r = 4$ m, $w = ?$, $g = 10$ m/s^2

Maximum tension–

$$T_{max} = \frac{mv^2}{r} + mg$$

$$T - mg = mr\omega^2$$

$$T = mg + mr\omega^2$$

$$3.7\text{ g} = 0.5\text{ g} + 0.5\times4\omega^2$$

$$3.2\text{ g} = 2\ \omega^2$$

$$\omega^2 = 16$$

$$\omega = 4 \text{ rad/s.}$$

649. A particle of mass 5 kg is moving on a circle of radius 1 m with an angular velocity of 2 rad.s^{-1}. The centripetal force is ______

(a) 10 N (b) 40 N
(c) 30 N (d) 20 N

AP EAMCET-25.08.2021, Shift-II

Ans. (d) : Given

That mass (m) = 5 kg
Radius of circle (r) = 1 m
Angular velocity (ω) = 2 rad/sec

We know,

$$\text{Centripetal force } (F_c) = \frac{mv^2}{r}$$

$$F_c = \frac{m(r\omega)^2}{r} \qquad (v = r\omega)$$

$$= \frac{mr^2\omega^2}{r}$$

$$F_c = mr\omega^2 = 5\times1\times(2)^2$$

$$F_c = 20 \text{ N}$$

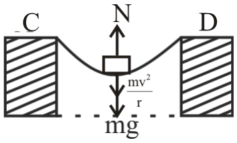
650. When a vehicle of mass m is moving with a velocity v over-bridge of radius of curvature r, the thrust on the road at the lowest point on the bridge, will be ______

(a) $mg + \frac{mv^2}{r}$ (b) $mg - \frac{mv^2}{r}$
(c) $\frac{m^2v^2g}{r}$ (d) $\frac{v^2g}{r}$

AP EAMCET-25.08.2021, Shift-I

Ans. (a) : The motion of the of the vehicle over a concave bridge CD is the motion along the segment of a circle.

The centripetal force is provided by the difference of normal reaction N of the bridge and weight mg of the car



$$\therefore \qquad N - mg = \frac{mv^2}{r}$$

$$N = mg + \frac{mv^2}{r}$$

651. One end of a string of length l is connected to a particle of mass m and the other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed v, the net force on the particle (directed towards the centre) is (T is the tension in the string)

(a) T (b) $T - \frac{mv^2}{l}$
(c) $T + \frac{mv^2}{l}$ (d) zero

Karnataka CET-2020
NEET-2017

Ans. (a) : When a partile revolves around the circular path of length l the centripetal force is provided by the tension produced in the string

Then,

$$\text{Net force } (F) = T = \frac{mv^2}{l}$$

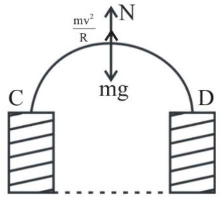
652. A car of mass 'm' is crossing the convex bridge of radius of curvature 'R' with a speed 'v'. At the highest point the thrust is (g = acceleration due to gravity)

(a) $mg + \frac{mv^2}{R}$ (b) mg
(c) $mg - \frac{mv^2}{R}$ (d) $\frac{mv^2}{R}$

MHT-CET 2020

@apna_pdf

Ans. (c) : The motion of the car over a convex bridge CD is the motion along the segment of a circle CD.



At the highest point the thrust is

$$mg - N = \frac{mv^2}{R}$$

So, $$N = mg - \frac{mv^2}{R}$$

Where,

N = Normal force
m = Mass
v = Velocity
R = Radius

653. A particle is moving in a circle of radius R with constant speed v. If radius is doubled, then its centripetal force to keep the same speed gets :

(a) Twice as great as before
(b) Half
(c) One-fourth
(d) Remains constant

BCECE-2005

Ans. (b) : $F = \frac{mv^2}{r}$

For same mass and same speed if radius is doubled then force should be halved because $F \propto \frac{1}{r}$.

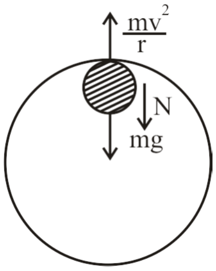
$$F' = \frac{mv^2}{2r} \Rightarrow \boxed{F' = \frac{1}{2}F}$$

654. In a circus, a stuntman rides a motor bike in a vertical circular track of radius r. Find the minimum speed, he must maintain at highest point of track.

(a) $\sqrt{2gr}$
(b) $2\sqrt{gr}$
(c) $\sqrt{gr}$
(d) $\sqrt{5gr}$

AP EAMCET (17.09.2020) Shift-II

Ans. (c) :



at highest point–

$$N + mg = \frac{mv^2}{r}$$

For V_{min}, N should be zero (i.e. N = 0)

Then,

$$\therefore \quad mg = \frac{mv^2}{r}$$

$$\therefore \quad V_{min} = \sqrt{gr}$$

Hence, minimum speed at the highest point of vertical circular path $V_{min} = \sqrt{gr}$

655. A particle is moving with a constant speed v in a circle. What is the magnitude of average velocity after half rotation?

(a) 2v
(b) $2\frac{v}{\pi}$
(c) $\frac{v}{2}$
(d) $\frac{v}{2\pi}$

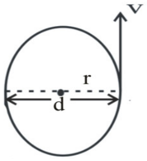
WB JEE 2011

Ans. (b) : We know that:-

d = 2r

Here, d is diameter and r is radius

In one complete rotation total distance covered = 2πr



Then,

For Half rotation–

$$\text{Distance covered} = \frac{2\pi r}{2} = \pi r$$

So, $$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{\pi r}{v}$$

Hence,

$$\text{Average velocity} = \frac{\text{total displacement}}{\text{total time}}$$

$$v = \frac{2r}{\frac{\pi r}{v}} = \frac{2v}{\pi}$$

656. A pellet of mass 1 g is moving with an angular velocity of 1 rad/s along a circle of radius 1 m. The centrifugal force is

(a) 0.1 dyne
(b) 1 dyne
(c) 10 dyne
(d) 100 dyne

WB JEE 2008

Ans. (d) : Given that,

m = 1 g, ω = 1 rad/sec
r = 1m = 100 cm

$$\text{Centrifugal force (f)} = \frac{mv^2}{r}$$

$$F = \frac{m(r\omega)^2}{r} \qquad (\because v = r\omega)$$

$F = mr\omega^2$, F = 1 × 100 × 1, F = 100 dyne

@apna_pdf

657. A car of mass 1500 kg is moving with a speed of 12.5 ms^{-1} on a circular path of radius 20 m on a level road. The value of coefficient of friction between the Tires and road, so that the car does. not slip is

(a) 0.8　　(b) 0.6

(c) 0.4　　(d) 0.2

UP CPMT-2009

Ans. (a) : Given that

Radius of the circular path = 20 m

Mass of the car = 1500 kg

Speed of the car = 12.5 m/sec

Let the coefficient of the friction be μ. the centrifugal force will balance the friction so that the car does not slip.

Hence,

car does not slip–

centripetal force = centrifugal force

$$\frac{mv^2}{r} = \mu mg \qquad [\because \text{centrifugal force} = \text{friction force}]$$

$$\text{coefficient of friction, } \mu = \frac{mv^2}{rmg}$$

$$\mu = \frac{v^2}{rg} = \frac{(12.5)^2}{20 \times 9.8}$$

$$\mu = 0.8$$

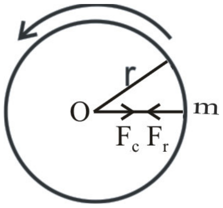
658. A particle of mass m is executing uniform circular motion on a path of radius r. If P is the magnitude of its linear momentum. The radial force acting on the particle is

(a) Pmr　　(b) $\frac{rm}{P}$

(c) $\frac{mP^2}{r}$　　(d) $\frac{P^2}{rm}$

UP CPMT-2009

Ans. (d) :



We know that,

Radial force = centripetal force

$$\text{Radial force } (F_r) = \frac{mv^2}{r} = \frac{mv^2}{r} \times \frac{m}{m}$$

$$F_r = \frac{(mv)^2}{rm}$$

$$F_r = \frac{P^2}{rm} \left\{ \begin{array}{l} \because P = mv \\ \text{Where. P is liner} \\ \text{Momentum} \\ \text{m = Mass} \\ \text{v = Velocity} \end{array} \right\}$$

659. Which motion does not require force to maintain it?

(a) Uniform circular motion

(b) Elliptical motion

(c) Uniform straight line motion

(d) Projectile motion

UP CPMT-2007

Ans. (c) : Uniform straight line motion is a type of linear motion. It work according to Newton's first law of motion i.e. objects that do not experience any net force will continue to move in straight line with a constant velocity until they are subjected to a net force.

660. If a_r and a_t represent radial and tangential accelerations, the motion of particle will be uniformly circular if

(a) $a_r = 0$ and $a_t = 0$　　(b) $a_r = 0$ but $a_t \neq 0$

(c) $a_r \neq 0$ but $a_t = 0$　　(d) $a_r \neq 0$ and $a_t \neq 0$

UP CPMT-2004

Ans. (c) : When the particle move uniform circular motion the tangential acceleration remains zero but magnitude of radial acceleration remains constant i.e. not zero.

Hence,

$a_r \neq 0$ but $a_t = 0$.

661. A small cone fitted with water is revolved in a vertical circle of radius 4 m and does not fall down. What must be the maximum period of revolution?

(a) 4s　　(b) 2s

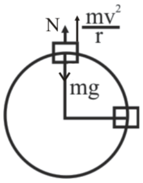
(c) 1s　　(d) 6s

UP CPMT-2012

Ans. (a) : Given that,

R = 4 m

g = 10 m/s^2



$$N = 0$$

$$\frac{mv^2}{r} \geq mg$$

$$\frac{v^2}{r} \geq g$$

$$v \geq \sqrt{rg}$$

$$r\omega \geq \sqrt{rg}$$

$$\omega \geq \sqrt{\frac{g}{r}}$$

$$\text{Time period, } (T) = \frac{2\pi}{\omega} \qquad (\because \ \omega = 2\pi n)$$

$$T \leq 2\pi\sqrt{\frac{r}{g}} \Rightarrow T \leq 2\pi\sqrt{\frac{4}{10}}$$

$$T = 3.97 \text{ second} \quad \approx 4 \text{ second.}$$

@apna_pdf

662. A cosmonaut is orbiting earth in a space craft at an altitude h = 630 km with a speed of 8 km/s. If the radius of the earth is 6370 km, the acceleration of the cosmonaut is

(a) 9.10 m/s^2 (b) 9.80 m/s^2
(c) 10.0 m/s^2 (d) 9.88 m/s^2

UP CPMT-2006

Ans. (a) : Given that,

h = 630 km

Speed (v) = 8 km/s

Radius of the earth (R_e) = 6370 km

The acceleration of the cosmonaut $(a) = \frac{v^2}{r}$

Where,

r = distance from the centre of the earth,

Then,

$r = R_e + h$

$r = 6370 + 630$

$= 7000 = 7\times10^6\,m$

We know that,

$$a_c = \frac{v^2}{r}$$

$$a_c = \frac{8\times8\times10^6}{7\times10^6}$$

$$a_c = \frac{64}{7} \Rightarrow a_c = 9.10\ m/s^2$$

663. A spaceman in training is rotated in a seat at the end of a horizontal arm of length 5m. If he can withstand accelerations upto 9g, then what is the maximum number of revolutions per second permissible ? (Take g = 10 m/s^2)

(a) 13.5 prs (b) 1.35 rps
(c) 0.676 rps (d) 6.75 rps

UP CPMT-2006

Ans. (c) : Given,

Length of horizontal arm (l) = r = 5m

Centripetal acceleration (a_c) = 9g

$= 90\ m/s^2$

We know that,

Centripetal acceleration $(a_c) = \frac{v^2}{r}$

$$v = \sqrt{a_c r}$$

$$v = \sqrt{90\times5}$$

$$v = 21.21\ m/s$$

As we know that, one revolution is equal to distance,

$d = 2\pi\times r$

$d = 2\pi\times5$

$= 31.42m$

Time taken for one complete revolution;

$$t = \frac{d}{v}$$

$$t = \frac{31.42}{21.21}$$

$$\boxed{t = 1.48s}$$

Then,

Number of revolutions $(n) = \frac{1}{t}$

$$n = \frac{1}{1.48} = 0.676\ rev/s$$

664. A particle of mass M is moving in a horizontal circle of radius R with uniform speed v. When the particle moves form one point to a diametrically opposite point, its

(a) Momentum does not change
(b) Momentum changes by 2 Mv
(c) Kinetic energy changes by $\frac{Mv^2}{4}$
(d) Kinetic energy changes by Mv^2

TS EAMCET (Engg.)-2017

Ans. (b) : Given

mass = M

horizontal circle of Radius = R

velocity of Particle = v

Change in momentum = Final momentum – initial momentum

$\Delta P = P_f - P_i$

$\Delta P = Mv - (-Mv)$

$= 2Mv$

Momentum change by 2 Mv.

665. A particle is moving in a circle of radius 5 cm with uniform speed and completes the circle in 5s. What is the magnitude of linear acceleration?

(a) $0.8\pi^2\ cm/s^2$ (b) $0.8\pi^2\ m/s^2$
(c) $0.8\pi\ cm/s^2$ (d) $0.8\pi\ m/s^2$

TS EAMCET 06.08.2021, Shift-II

Ans. (a) : Given, r = 5cm, t = 5sec.

The linear speed $(v) = \frac{2\pi r}{t} = \frac{2\pi\times5}{5} = 2\pi\ cm/s$

Centripetal acceleration $(a) = \frac{v^2}{r} = \frac{(2\pi)^2}{5} = \frac{4\pi^2}{5}$

$$a = 0.8\pi^2\ cm/s^2$$

Hence, the magnitude of its acceleration = $0.8\pi^2\ cm/s^2$

666. In uniform circular motion which of following statement is wrong

(a) Work done during one complete cycle is zero
(b) Centripetal force acting towards the centre of circle
(c) Angular velocity is constant
(d) Tangential velocity is constant

TS EAMCET 06.08.2021, Shift-II

Ans. (d) : In a uniform circular motion, speed of the particle does not change whereas direction changes. Hence,

Tangential velocity changes at every instant.

@apna_pdf

667. A particle moves according to the equation x = a sinωt and y = a (1-cosωt). The path of the particle is

(a) circle (b) parabola
(c) hyperbola (d) cycloid

SRMJEE - 2016

Ans. (d) : Motion of the particle is given by the equations

$$x = a\sin\omega t$$

$$\frac{x}{a} = \sin\omega t \qquad \text{...... (i)}$$

$$y = a(1-\cos\omega t) \Rightarrow \frac{y}{a} - 1 = -\cos\omega t \qquad \text{..... (ii)}$$

Squaring and adding eqns. (i) and (ii), we get.

$$\frac{x^2}{a^2} + \left(\frac{y}{a} - 1\right)^2 = 1$$

$$x^2 + (y-a)^2 = a^2$$

This is the equation of a cycloid.

668. Two stones of masses m and 2m are whirled in horizontal circles, the heavier one in a radius $\frac{r}{2}$ and the lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when they experience same centripetal forces. The value of n is

(a) 2 (b) 3
(c) 4 (d) 1

[AIPMT 2015]

Ans. (a) : Mass of lighter stone (m_L) = m
Mass of heavier stone (m_H) = 2m
Radius of lighter stone (r_L) = r
Radius of heavier stone (r_H) = $\frac{r}{2}$

$$F_{CL} = F_{CH} \rightarrow \boxed{v_L = nv_H} \qquad \begin{bmatrix} \text{Centripetal force of lighter} = F_{CL} \\ \text{Centripetal force of heavier} = F_{CH} \end{bmatrix}$$

We know that,

$$F_{CL} = F_{CH}$$

$$\frac{m_L v_L^2}{r_L} = \frac{m_H v_H^2}{r_H}$$

Putting the value of

$$\frac{m(nv_H)^2}{r} = \frac{2m(v_H)^2}{\frac{r}{2}}$$

$$n^2 = \frac{2}{\frac{1}{2}} = \frac{2\times 2}{1}$$

$$n^2 = 4$$

$$n = 2$$

669. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2π s. The acceleration of the particle is

(a) 25 m/s^2 (b) 36 m/s^2
(c) 5 m/s^2 (d) 15 m/s^2

[AIPMT 2011]

Ans. (c) : For tangential acceleration-
If v = constant

$$a_t = \frac{dv}{dt} \quad (v = \text{constant})$$

$$a_t = 0$$

For centripetal acceleration -

$$a_C = \frac{v^2}{r}$$

$$a_C = \omega^2 n$$

$$T = 0.2\,\pi \text{ sec.}$$

$$\omega = \frac{2\pi}{T}$$

$$\omega = \frac{2\pi}{0.2\pi} = 10 \text{ rad/s}$$

$$\therefore \quad a = a_C$$

$$= \omega^2 r$$

$$= 100 \times \frac{5}{100}$$

$$a = 5 \text{ m/s}^2$$

Acceleration of the particle is (a) = 5 m/s^2

670. A car runs at a constant speed on a circular track of radius 100 m, taking 62.8 s for every circular lap. The average velocity and average speed for each circular lap respectively is

(a) 0, 0 (b) 0, 10 m/s
(c) 10 m/s, 10 m/s (d) 10 m/s, 0

[AIPMT 2006]

Ans. (b) : Given,
t = 62.8 sec, r = 100 m
∵ Car runs circular track
Hence, total displacement = 0

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$\vec{v} = \frac{0}{t} = 0$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{2\pi r}{t}$$

$$= \frac{2\pi\times 100}{62.8}$$

$$= \frac{2\times 3.14\times 100}{62.8}$$

$$= 10 \text{ m/s}$$

671. The circular motion of a particle with constant speed is

(a) simple harmonic but not periodic
(b) periodic and simple harmonic
(c) neither periodic nor simple harmonic
(d) periodic but not simple harmonic

[AIPMT 2005]

@apna_pdf

Ans. (d) : The circular motion of a particle with constant speed is periodic but not simple harmonic.

- Due to constant speed, the object will cover equal distance in equal intervals of time. Hence, the circular motion will be repeated in equal intervals of time. So it is a periodic motion.
- In a circular motion, the object cannot oscillate about a fixed position as it travels circular distance.

This, it is not a simple harmonic motion.

672. A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the velocity of the particle is 80m/s at the end of the second revolution after motion has begin, the tangential acceleration is

(a) $160\ \pi\ m/s^2$
(b) $40\ m/s^2$
(c) $40\ \pi\ m/s^2$
(d) $640\ \pi\ m/s^2$

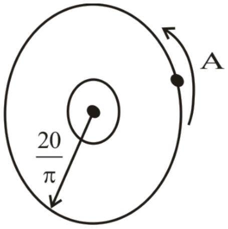
[AIPMT 2003]

Ans. (b) : Given,

$$R = \left(\frac{20}{\pi}\right)m,\ \theta = 2\pi$$

velocity = 80 m/s, after 2 rounds

initial angular velocity, $\omega_0 = 0$



$$\omega^2 = \omega_0{}^2 + 2\alpha\theta \qquad \left[\begin{matrix}\because v = r\omega \\ \omega = \frac{v}{r}\end{matrix}\right]$$

$$\frac{v^2}{r^2} = 0 + 2\times\frac{a}{r}\times(2\pi)\times 2 \qquad \left[\begin{matrix}\because a = r^2 \\ a = \frac{a}{r}\end{matrix}\right]$$

$$\frac{(80)^2}{r^2} = 2\times\frac{a}{r}\times 2\pi\times 2$$

$$\frac{80\times 80\times\pi}{20} = 2\times a\times 4\pi \qquad \left[r = \frac{20}{\pi}\right]$$

$$\boxed{a = 40\,m/s^2}$$

673. A particle of mass M is revolving along a circle of radius R and another particle of mass m is revolving in a circle of radius r. If time periods of both particles are same, then the ratio of their angular velocities is

(a) 1
(b) $\frac{R}{r}$
(c) $\frac{r}{R}$
(d) $\sqrt{\frac{R}{r}}$

[AIPMT 2001]

Ans. (a) : Angular velocity of particle is given by

$$\omega = \frac{2\pi}{T}$$

Or

$$\omega \propto \frac{1}{T} \qquad [\because T = \text{time period of the particle}]$$

It simply implies that ω does not depend on mass of the body and radius of the circle

$$\frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$$

but given time period is same (i.e. $T_1 = T_2$)

Hence, $\frac{\omega_1}{\omega_2} = \frac{1}{1}$

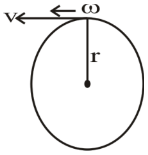
674. A body is whirled in a horizontal circle of radius 20 cm. It has an angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?

(a) $\sqrt{2}$ m/s
(b) 2 m/s
(c) 10 m/s
(d) 20 m/s

[CBSE AIPMT 1996]

Ans. (b) : Angular velocity (ω) = 10 rad/s

Circular Radius (r) = 20 cm ⇒ 0.2 m



We know that,

$$v = r\omega$$

$$v = 0.2\times 10 \Rightarrow v = 2\,m/s$$

675. When milk is churned, cream gets separated due to

(a) centripetal force
(b) centrifugal force
(c) frictional force
(d) gravitational force

[AIPMT 1991]

Ans. (b) : Due to centrifugal force, the cream gets separated when milk is churned. A common way of separating cream from milk by churning is using the centrifuge machine. When the machine rotates, the heavier part (cream) moves outward, due to centrifugal force, and thus gets separated from the milk.

676. An electric fan has blades of length 30 cm measured from the axis of rotation. If the fan is rotating at 120 rev/min, the acceleration of a point on the tip of the blade is

(a) $1600\ ms^{-2}$
(b) $47.4\ ms^{-2}$
(c) $23.7\ ms^{-2}$
(d) $50.55\ ms^{-2}$

[AIPMT 1990]

Ans. (b) : Given,

r = 30 cm = 0.3 m

n = 120 rev/min

$$n = \frac{120}{60} = 2 \text{ rev/sec}$$

@apna_pdf

$\omega = 2\pi n$

$\omega = 2\times\pi\times2$

$\omega = 4\pi$ rad/sec

Then,

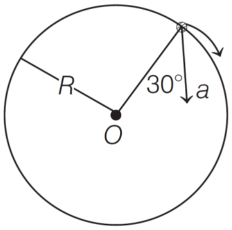
Acceleration, $a_c = \omega^2 r$

$a_c = (4\pi)^2 \times 0.3$

$= \dfrac{16\times22\times22\times0.3}{7\times7}$

$a_c = 47.4\,\text{m/s}^2$

677. In the given figure, a =15 m/s^2 represents the total acceleration of a particle moving in the clockwise direction in a circle of radius R = 2.5 m at a given instant of time. The speed of the particle is

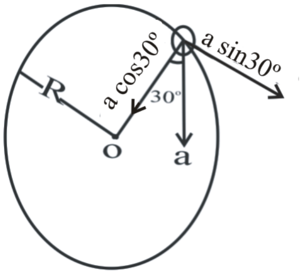


(a) 4.5 m/s (b) 5.0 m/s

(c) 5.7 m/s (d) 6.2 m/s

[NEET 2016]

Ans. (c) : Given, R = 2.5 m, a = 15 m/s^2, $a_c = a\cos30^o$



We know that,

Centripetal acceleration, $a_c = \dfrac{v^2}{R}$

$a\cos30^o = \dfrac{v^2}{R}$

$\dfrac{v^2}{2.5} = 15\times\dfrac{\sqrt{3}}{2}$

$v^2 = 32.475$

v = 5.69 m/s

v = 5.7 m/s

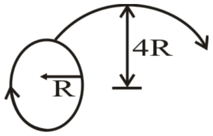
678. A particle moving in a circle of radius R with a uniform speed takes a time T to complete one revolution. If this particle were projected with the same speed at an angle θ to the horizontal, the maximum height attained by it equals 4R. The angle of projection θ is then given by

(a) $\theta = \cos^{-1}\left(\dfrac{gT^2}{\pi^2 R}\right)^{\frac{1}{2}}$ (b) $\theta = \cos^{-1}\left(\dfrac{\pi^2 R}{gT^2}\right)^{\frac{1}{2}}$

(c) $\theta = \sin^{-1}\left(\dfrac{\pi^2 R}{gT^2}\right)^{\frac{1}{2}}$ (d) $\theta = \sin^{-1}\left(\dfrac{2gT^2}{\pi^2 R}\right)^{\frac{1}{2}}$

[NEET 2021]

Ans. (d) : Given, maximum height H = 4R



Time, $T = \dfrac{2\pi R}{V}$

or $V = \dfrac{2\pi R}{T}$ ....(i)

maximum height, $H_{max} = \dfrac{V^2\sin^2\theta}{2g} = \dfrac{2\pi^2R^2\sin^2\theta}{gT^2}$

$4R = \dfrac{2\pi^2R^2\sin^2\theta}{gT^2}$

$\sin\theta = \left(\dfrac{2gT^2}{\pi^2R}\right)^{1/2}$

$\theta = \sin^{-1}\left(\dfrac{2gT^2}{\pi^2R}\right)^{1/2}$

679. A particle moves in a circle of radius 30 cm. Its linear speed is given by v =2t where t in second and v in m/s. Find out its radial and tangential acceleration at t = 3 sec. respectively.

(a) 220m/sec^2, 50m/sec^2

(b) 100m/sec^2, 5m/sec^2

(c) 120m/sec^2, 2m/sec^2

(d) 110m/sec^2, 10m/sec^2

MP PET-2008

Ans. (c) : Given,

Radius of circle (r) = 30 cm

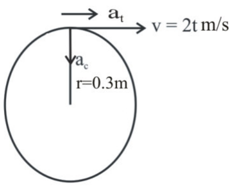
Linear speed of particle (v) = 2t

For, t = 3,

We have to find,

Radial acceleration (a_c) = ?

Tangential acceleration (a_t) = ?



We know that tangential acceleration-

$a_t = \dfrac{dv}{dt}$

$a_t = \dfrac{d}{dt}(2t)$

$a_t = 2\text{m/sec}^2$

@apna_pdf

Radial acceleration/centripetal acceleration,

$$a_C = v^2/r = \frac{(2t)^2}{r}$$

$$a_C = \frac{4t^2}{0.3}$$

$$a_C = \frac{40}{3}(t)^2 \qquad \text{(at } t = 3 \text{ second)}$$

$$a_C = \frac{40}{3}(3)^2$$

$$= 120 \text{ m/sec}^2$$

680. A weightless thread can bear tension upto 37 N. A stone of mass 500g is tied to it and revolved in a circular path of radius 4 m in a vertical plane. If g = 10ms^{-2}, then the maximum angular velocity of the stone will be

(a) 2 rad s^{-1} (b) 4 rad s^{-1}

(c) 8 rad s^{-1} (d) 16 rad s^{-1}

JIPMER-2010

Ans. (b) : Given,

T_{max} = 37 N, m = 500g = 0.5kg,

g = 10ms^{-2}, r = 4m

Maximum tension in the thread is given by-

$$T_{max} = mg + \frac{mv^2}{r}$$

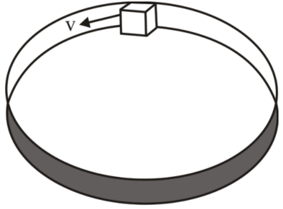
or $$T_{max} = mg + mr\omega^2 \qquad [\because v = r\omega]$$

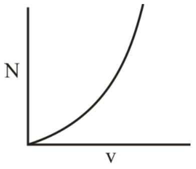
or $$\omega^2 = \frac{T_{max} - mg}{mr}$$

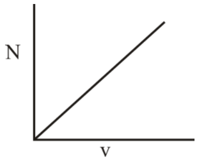
$$\therefore \quad \omega^2 = \frac{37 - 0.5\times10}{0.5\times4} = \frac{37-5}{2}$$

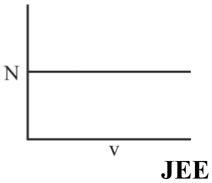
or $\omega^2 = 16$ or $\omega = 4$ rad s^{-1}

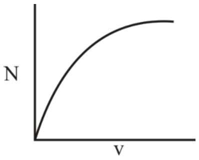
681. A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v) ?



(a)


(b)


(c)


(d)


JEE Main-29.07.2022, Shift-I

Ans. (a) : Given,

Mass of block = m

Speed of block = v

Relation between normal reaction on the block by wall is equal to on the block normal reaction is provided by centripetal acceleration.

Hence,

$$N = \frac{mv^2}{r}$$

$$y \propto kx^2$$

So, it is represented parabola curve.

682. Motion of particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ m and y = 4sin(ωt)m. The path of the particle will be

(a) Circular (b) Helical

(c) Parabolic (d) Elliptical

JEE Main-28.06.2022, Shift-I

Ans. (a) : Given,

$$x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$$

$$x = 4\cos\omega t \qquad ....(i)$$

and $$y = 4\sin\omega t \qquad ....(ii)$$

Squaring and adding equation (i) and (ii), We get

$$x^2 + y^2 = 16\cos^2\omega t + 16\sin^2\omega t$$

$$x^2 + y^2 = 16\,(1)$$

$$\boxed{x^2 + y^2 = 16}$$

This is the equation of the circle.

683. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80N. If the maximum speed with which the stone can revolve is $\frac{K}{\pi}$ rev./min. The value of K is.

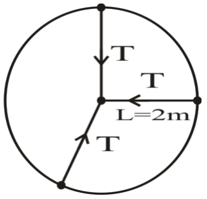
(Assume the string is mass less and unstretchable)

(a) 400 (b) 300

(c) 600 (d) 800

JEE Main-24.06.2022, Shift-I

Ans. (c) : Given, m = 100 g, L = 2 m, T_{max} = 80 N



Tension, $T = m r \omega^2$

$$T_{max} = m L \omega^2_{max} \qquad (\because r = L)$$

$$80 = 100\times10^{-3}\times2\times\omega^2_{max}$$

$$\omega^2_{max} = \frac{80}{0.2}$$

@apna_pdf

$$\omega^2_{max} = 400$$

$$\boxed{\omega_{max} = 20\,\text{rad/sec}}$$

$$\omega_{max} = \frac{20}{\frac{2\pi}{60}}$$

$$\omega_{max} = \frac{600}{\pi}\text{rpm}$$

$$\frac{K}{\pi} = \frac{600}{\pi}$$

$$\boxed{K = 600\,\text{rpm}}$$

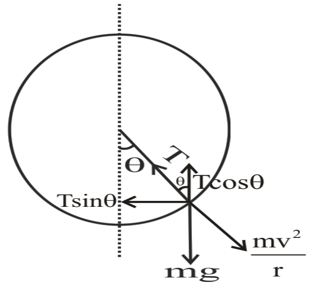
684. A stone of mass m, tied to a string is being whirled in a vertical circle with a uniform speed. The tension in the string is

(a) The same throughout the motion
(b) minimum at the highest position of the circular path
(c) minimum at the lowest position of the circular path
(d) minimum when the rope is in the horizontal position

JEE Main-24.06.2022, Shift-II

Ans. (b) : At, angle θ

$$T - mg\cos\theta = \frac{mv^2}{R}$$



Here, v is constant,

T will be minimum when cos θ is minimum.

θ = 180° corresponds to $T_{minimum}$

So, the tension in the string is minimum at the highest position of the circular path.

685. For a particle in uniform circular motion, the acceleration $\vec{a}$ at any point P(R, θ) on the circular path of radius R is (when θ is measured from the positive x-axis and v is uniform speed):

(a) $-\frac{v^2}{R}\sin\theta\hat{i} + \frac{v^2}{R}\cos\theta\hat{j}$

(b) $-\frac{v^2}{R}\cos\theta\hat{i} + \frac{v^2}{R}\sin\theta\hat{j}$

(c) $-\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$

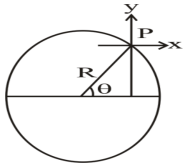
(d) $-\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

JEE Main-25.06.2022, Shift-II

Ans. (c) : Acceleration, $\vec{a} = a_c = \frac{v^2}{R}$

At x-axis,

$$a_x = -a_c\cos\theta\hat{i}$$



At y-axis,

$$a_y = -a_c\sin\theta\hat{j}$$

Resultant acceleration, $\vec{a} = a_x\hat{i} + a_y\hat{j}$

$$= -a_c\cos\theta\hat{i} - a_c\sin\theta\hat{j}$$

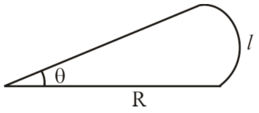
$$\vec{a} = -\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$$

686. A huge circular arc of length 4.4 ly subtends an angle 4s at the centre of the circle. How long it would take for a body to complete 4 revolution if its speed is 8 AU per sec ?
[Given, $1\,\text{ly} = 9.46\times10^{15}\,\text{m}, 1\,\text{AU} = 1.5\times10^{11}\,\text{m}$]

(a) 4.1×10^8 s
(b) 4.5×10^{10} s
(c) 3.5×10^6 s
(d) 7.2×10^8 s

JEE Main-27.08.2021, Shift-I

Ans. (b) Given, length of arc = 4.4 ly
= 4.4 × 9.46 × 10^{15}



We know that,

Radius, R = l/θ

$$\text{Time}, t = \frac{4\times2\pi R}{v} = \frac{4\times2\pi}{v}\left(\frac{l}{\theta}\right)$$

Put l = 4.4 × 9.46 × 10^{15}
v = 8 × 1.5 × 10^{11}

$$\theta = \frac{4}{3600}\times\frac{\pi}{180}\text{rad.}$$

Putting the value,
t = 4.5 × 10^{10} sec.

687. A clock has a continuously moving second's hand of 0.1m length. The average acceleration of the tip of the hand (in ms^{-2}) is of the order of

(a) 10^{-3}
(b) 10^{-4}
(c) 10^{-2}
(d) 10^{-1}

JEE Main-06.09.2020, Shift-I

Ans. (a) : Given, length of second's hand = 0.1 m
As we know that,

Avg. acceleration, $a = \frac{v^2}{R}$ and $v = \frac{2\pi R}{60}$

So, $$a = \frac{(2\pi R)^2}{60^2\times R} = \frac{4\pi^2R^2}{60^2R}$$

$$= \frac{4\times(3.14)^2\times0.1}{60^2} = 10^{-3}\,\text{m/s}^2$$

@apna_pdf

688. A particle moves such that its position vector $r(t) = \cos\omega t\hat{i} + \sin\omega t\hat{j}$, where ω is a constant and t is time. Then, which of the following statements is true for the velocity v(t) and acceleration a(t) of the particle?

(a) **v** and **a** both are parallel to **r**.
(b) **v** is perpendicular to **r** and **a** is directed away from the origin.
(c) **v** and **a** both are perpendicular to **r**.
(d) **v** is perpendicular to **r** and **a** is directed towards the origin.

JEE Main-08.01.2020, Shift-II

Ans. (d) : Given,

Position vector, $\vec{r}(t) = \cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}$

Where, ω = constant, t = time

Velocity, $\vec{v} = \frac{dr}{dt} = \omega\left[-\sin\omega t\,\hat{i} + \cos\omega t\,\hat{j}\right]$

Acceleration, $\vec{a} = \frac{dv}{dt} = -\omega^2\left[\cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}\right] = -\omega^2\vec{r}$

Here, negative sign indicates that acceleration is in opposite direction of r.

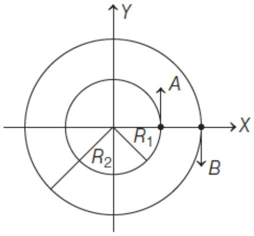
For velocity direction we can take product of v and r–

$\vec{v}\cdot\vec{r} = \omega\left(-\sin\omega t\,\hat{i} + \cos\omega t\,\hat{j}\right)\left(\cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}\right)$

$= \omega\left(-\sin\omega t\cos\omega t + \cos\omega t\,\sin\omega t\right) = 0$

This implies that $\vec{v}$ is perpendicular to $\vec{r}$ and a is directed towards the origin.

689. Two particles A and B are moving on two concentric circles of radii R_1 and R_2 with equal angular speed ω. At t =0, their positions and direction of motion are shown in the figure



The relative velocity $v_A - v_B$ at $t = \frac{\pi}{2\omega}$ is given by

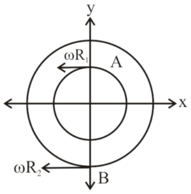
(a) $\omega(R_1 + R_2)\hat{i}$
(b) $-\omega(R_1 + R_2)\hat{i}$
(c) $\omega(R_1 - R_2)\hat{i}$
(d) $\omega(R_2 - R_1)\hat{i}$

JEE Main-12.01.2019, Shift-II

Ans. (d) : Given, radii of concentric circle = R_1 and R_2,

Time, $t = \frac{\pi}{2\omega}$

Angular speed = ω, time, t = 0



$$\theta = \omega t = \omega\frac{\pi}{2\omega} = \frac{\pi}{2}$$

$$v_A - v_B = \omega R_1\left(-\hat{i}\right) - \omega R_2\left(-\hat{i}\right)$$

$$= -\omega R_1\,\hat{i} + \omega R_2\,\hat{i}$$

$$= \omega\left(R_2 - R_1\right)\hat{i}$$

690. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2, respectively. Their speeds are such that they make complete circles in the same time t. The ratio of their centripetal acceleration is

(a) $m_1r_1 : m_2r_2$
(b) $m_1 : m_2$
(c) $r_1 : r_2$
(d) 1:1

AIEEE 2021

Ans. (c) : Given,

Mass of two cars are m_1 and m_2.

Radii of circle are r_1 and r_2, time = t

Centripetal acceleration $(a_c) = \omega^2 r$

$$= \left(\frac{2\pi}{t}\right)^2 r \qquad \left(\because \omega = \frac{2\pi}{t}\right)$$

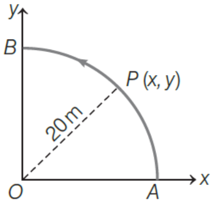
$$a_c = \frac{4\pi^2}{t^2}r$$

As time period for both cars is same. So, we can say–

$$a_c \propto r$$

Then, $\frac{a_1}{a_2} = \frac{r_1}{r_2}$

691. A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of P is such that it sweeps out a length $s = t^3 + 5$, where s is in metre and t is in second. The radius of the path is 20m. The acceleration of P when t =2s is nearly

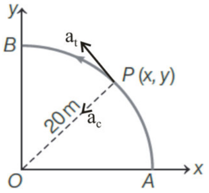


(a) 13 ms^{-2}
(b) 12 ms^{-2}
(c) 7.2 ms^{-2}
(d) 14 ms^{-2}

AIEEE-2010

Ans. (d) : Given, length (s) = t^3 + 5

Radius of path = 20 m, time = 2s



$\because \qquad s = t^3 + 5$

@apna_pdf

Differentiating w.r.t. to t, we get–

$$v = \frac{ds}{dt} = 3t^2 \text{ m/s} \qquad \left(\because v = \frac{ds}{dt}\right)$$

$$a_t = \frac{dv}{dt} = 6t \text{ m/s}^2$$

At, t = 2 sec

$$a_t = 12 \text{ m/s}^2$$

As we know,

$$\text{Centripetal acceleration } (a_c) = \frac{v^2}{R} = \frac{(3t^2)^2}{20} = \frac{9t^4}{20}$$

At t = 2 sec

$$a_c = \frac{9 \times 2^4}{20} = 7.2 \text{ m/s}^2$$

At t = 2 sec

$$a = \sqrt{a_t^2 + a_c^2}$$

$$a = \sqrt{12^2 + (7.2)^2} = \sqrt{144 + 51.84} = \sqrt{195.84}$$

$$a \approx 14 \text{ m/s}^2$$

692. Which of the following statements is false for a particle moving in a circle with a constant angular speed?

(a) The velocity vector is tangent to the circle
(b) The acceleration vector is tangent to the circle
(c) The acceleration vector points to the centre of the circle
(d) The velocity and acceleration vectors are perpendicular to each other

AIEEE 2004

Ans. (b) : Here, option (b) is a false statement because a particle moving in a circle with a constant angular speed has only centripetal acceleration and no tangential acceleration.

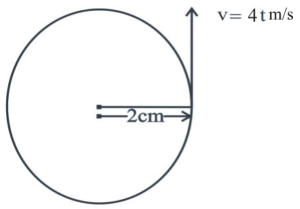
693. A particle moves in a circle of radius 2 cm at a speed given by v = 4t. The tangential acceleration at t = 1s is

(a) 6cms^{-2} (b) 2.5cms^{-2}
(c) 3cms^{-2} (d) 4cms^{-2}

Assam CEE-31.07.2022

Ans. (d) : Given, r = 2 cm

v = 4t



$$\text{Tangential acceleration } (a_T) = \frac{dv}{dt}$$

$$(a_T) = \frac{d}{dt}4t$$

$$(a_T) = 4\text{cm/s}^2$$

694. A bucket full of water is rotated in a vertical in a circular path 1.6 m For what expected maximum time period of revolution, water will not spill out from the bucket?

(a) 1.5 s (b) 2.5 s
(c) 3.5 s (d) 4.5 s

Tripura-27.04.2022

Ans. (b) : Given, Radius = 1.6 m

As the bucket is rotating, centrifugal force acts on it. Centrifugal force should be greater than gravitational force so that the water does not fall out of the bucket.

$$F = F_c$$

$$mg = \frac{mv^2}{r} = \frac{m\omega^2 r^2}{r} \qquad (v = r.\omega)$$

$$mg = m\omega^2 r \qquad (\omega = 2\pi/t)$$

$$g = \frac{4\pi^2}{t^2} \times r$$

$$t^2 = \frac{4\pi^2}{g} \times r = \frac{4 \times (3.14)^2 \times (1.6)}{10}$$

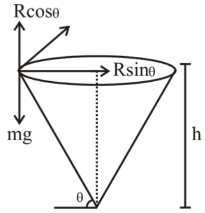
$$t^2 = 6.31 \Rightarrow t = \sqrt{6.31} = 2.51 \text{ sec.}$$

695. A small ball describes a horizontal circle on the smooth inner surface of a conical funnel. If the height of the plane of the circle above the vertex be 10 cm. What is the speed of the particle.

(a) 2 m/s (b) 4 m/s
(c) 16 m/s (d) 1 m/s

HP CET-2018

Ans. (d) : Given, h = 10 cm = 0.1 m
g = 10 m/s²



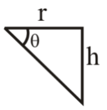
$$R\sin\theta = \frac{mv^2}{r} \qquad ....(i)$$

$$R\cos\theta = mg \qquad ....(ii)$$

So, from equation (i) and (ii),

$$\tan\theta = \frac{v^2}{rg}$$

Now,



$$\Rightarrow \tan\theta = \frac{h}{r}$$

So,

$$\frac{h}{r} = \frac{v^2}{rg}$$

$$v = \sqrt{hg} = \sqrt{0.1 \times 10} = 1 \text{ m/s}$$

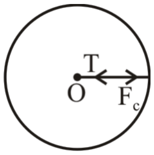
@apna_pdf

696. A stone of mass 0.3 kg attached to a 1.5 m long string is whirled around in a horizontal circle at a speed of 6 meter per second (m/s). The tension in the string is

(a) 10 N (b) 20 N
(c) 7.2 N (d) None

HP CET-2018

Ans. (c) : Given that,
Mass of stone (m) = 0.3 kg
Radius of circle (R) = 1.5 m
Speed (v) = 6m/s



According to question,

$$\text{Tension}(T) = \frac{mv^2}{R} = \frac{(0.3)(6)^2}{1.5}$$

$$T = \frac{0.3 \times 36}{1.5}$$

$$T = 7.2 \text{ N}$$

697. A body is whirled in a horizontal circle of radius 25 cm. It has an angular velocity of 13 rad/s. What is its linear velocity at any point on circular path ?

(a) 2 m/s (b) 3 m/s
(c) 3.25 m/s (d) 4.25 m/s

JIPMER-2016

Ans. (c) : Given that, r = 25 cm = 0.25 m, ω = 13 rad/sec
We know that,

$$v = r\omega$$

$$v = 0.25 \times 13$$

$$v = 3.25 \text{ m/sec}$$

698. What should the angular speed of earth be, for a body lying on the equator to feel weightlessness? ($g = 10 \text{ m.s}^{-2}$, R = 6400 km)

(a) $\frac{1}{800}\text{rad.s}^{-1}$ (b) $\frac{1}{400}\text{rad.s}^{-1}$
(c) $\frac{1}{600}\text{rad.s}^{-1}$ (d) $\frac{1}{100}\text{rad.s}^{-1}$

AP EAMCET-25.09.2020, Shift-II

Ans. (a) : Given,

$g = 10 \text{ m/s}^2$
$R = 6400 \text{ km} = 6400 \times 10^3 \text{m}$

As we know apparent weight of body at equator–

$$w' = w - mR\omega^2$$

As the body feel weightlessness i.e. $w' = 0$

$$w = mR\omega^2$$

$$mg = mR\omega^2$$

$$\omega^2 = \frac{g}{R}$$

$$\omega = \sqrt{\frac{g}{R}}$$

$$\omega = \sqrt{\frac{10}{6400 \times 10^3}}$$

$$\omega = \frac{1}{800} \text{Rad/s}$$

699. A train runs along an unbanked circular track of radius 30 m at a speed of 54 kmph. The mass of the train is 10^6 kg. Then find the angle of banking required to prevent wearing out the rail.

(a) $\text{Tan}^{-1}\left(\frac{1}{2}\right)$ (b) $\text{Tan}^{-1}\left(\frac{3}{4}\right)$
(c) $\text{Tan}^{-1}\left(\frac{5}{6}\right)$ (d) $\text{Tan}^{-1}(1)$

AP EAMCET-24.08.2021, Shift-I
AP EAMCET-25.09.2020, Shift-II

Ans. (b) : Given, $m = 10^6$ kg

$v = 54$ km/h

$$v = 54 \times \frac{5}{18} = 15 \text{ m/s}$$

r = 30m

Centripetal force is provided by lateral thrust. Force which is by rail on the wheel.
For safe speed,

$$\text{Tan}\,\theta = \frac{v^2}{rg}$$

$$= \frac{(15)^2}{30 \times 10}$$

$$= \frac{225}{30 \times 10}$$

$$\therefore \quad \theta = \text{Tan}^{-1}\left(\frac{3}{4}\right)$$

700. A body moving along a circular path due to a centripetal force having constant magnitude is an example of motion with ______

(a) Constant speed and constant velocity
(b) Variable speed and variable velocity
(c) Variable speed and constant velocity
(d) Constant speed and variable velocity

AP EAMCET-24.09.2020, Shift-I

Ans. (d) : A body moving along a circular path due to a centripetal force having constant magnitude is an example of motion with constant speed and variable velocity.

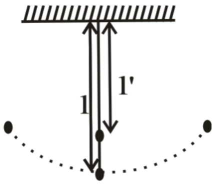
701. The period of swing for a girl swinging on a swing in her sitting position is T. If she suddenly starts swinging by standing on the swing, its period _______

(a) decreases (b) increases
(c) remains constant (d) becomes zero

AP EAMCET (Medical)-07.10.2020, Shift-I

@apna_pdf

Ans. (a) :



When girl swinging in sitting position, Time period is T.

We know that

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T \propto \sqrt{l}$$

When girl swinging by standing position the effective length will decreases, so time period will also decreases.

702. The kinetic energy of a circular disc rotating with a speed of 60 rpm about an axis passing through a point on its circumference and perpendicular to its plane is (mass of circular disc = 5 kg, radius of disc = 1m) approximately.

(a) 170 J (b) 160 J

(c) 150 J (d) 140 J

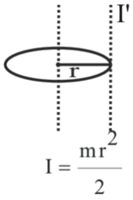
AP EAMCET -2015

Ans. (c) : Given, n = 60 rpm

$$\omega = 2\pi n = 2\pi\times\frac{60}{60} \qquad (\because 1\text{m} = 60\text{sec})$$

$$\omega = 2\pi \text{ radian/sec}$$

$$m = 5 \text{ kg}, \ r = 1 \text{ m}$$



$$I' = I_G + mr^2$$

$$I' = \frac{mr^2}{2} + mr^2 = \frac{3}{2}mr^2 \qquad \left[I_G = \frac{mr^2}{2}\right]$$

$$KE = \frac{1}{2}I'\omega^2$$

$$KE = \frac{1}{2}\times\frac{3}{2}\times5\times(1)^2\times\omega^2$$

$$KE = \frac{3}{4}\times5\times(1)^2\times(2\pi)^2$$

$$KE = \frac{15\times4\pi^2}{4}$$

$$KE = 15\pi^2 \text{ J} = 15\times\frac{22}{7}\times\frac{22}{7}\text{ J}$$

$$\boxed{KE = 148.04\text{J} \approx 150\text{J}}$$

703. A particle is moving in a circle and is uniformly gaining speed. Match the following physical quantities.

Column-I	Column-II
A. Tangential acceleration	$\frac{d\omega}{dt}$
B. Radial acceleration	Constant
C. Angular acceleration	Variable
D. Angular momentum	Iω

(a) (A–iv),(B–iii),(C–ii),(D–i)

(b) (A–iii),(B–iv),(C–i),(D–ii)

(c) (A–ii),(B–iii),(C–i),(D–iv)

(d) (A–i),(B–ii),(C–iv),(D–iii)

AP EAMCET-03.09.2021, Shift-II

Ans. (c) :

Column-I	Column-II
A.Tangential acceleration	(i) Constant
B. Radial acceleration	(ii) Variable
C. Angular acceleration	(iii) dω/dt
D. Angular momentum	(iv) Iω

704. An insect trapped in a circular groove of radius 12 cm moves along the groove steadily and completes 7 revolutions in 100 seconds. The linear speed of the insect is___

(a) 4.3 cm.s^{-1} (b) 5.3 cm.s^{-1}

(c) 6.3 cm.s^{-1} (d) 7.3 cm.s^{-1}

AP EAMCET-03.09.2021, Shift-II

Ans. (b) :

$\therefore$ Time taken to complete 1 revolution (T) = $\frac{100}{7}$

$\therefore$ r = 12 cm

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{100/7} = \frac{2\pi\times7}{100} = \frac{14\pi}{100} = 0.44 \text{ rad./sec}$$

Now, linear speed is-

$$v = r\omega$$

$$v = 12 \times 0.44$$

$$v = 5.3 \text{ cm/sec}$$

705. A cycle turns around a curved at 25 miles per hour. If the turns at double the speed. The tendency to overturn is______

(a) Doubled (b) Halved

(c) Quadrupled (d) Unchanged

AP EAMCET-03.09.2021, Shift-II

Ans. (c) : Given,

Speed of cycle when cycle turns around curved (v_1) = 25 miles/hr

Then, centripetal force,

$$F_c = \frac{mv_1^2}{r} \qquad ....(i)$$

@apna_pdf

Again, when it turns double the speed, $v' = 2v_1$
then, centripetal force is,

$$F_c' = \frac{m(v')^2}{r}$$

$$F_c' = \frac{m(2v_1)^2}{r}$$

$$F_c' = \frac{4mv_1^2}{r} \qquad \text{....(ii)}$$

Now, equation (ii) ÷ (i)

$$\frac{F_c'}{F_c} = \frac{\frac{4mv_1^2}{r}}{\frac{mv_1^2}{r}}$$

$$F_c' = 4F_c$$

Here, the tendency to overturn is quadrupled.

706. When a particle is moving in a circular track of radius 40 cm with a constant speed of 8m.s^{-1}. Its acceleration is ________.

(a) 320 m.s^{-2} (b) 120 m.s^{-2}
(c) 160 m.s^{-2} (d) 80 m.s^{-2}

AP EAMCET-07.09.2021, Shift-I

Ans. (c) : Given that, radius of circular track (R) = 40 cm= 0.4 m
Speed (v) = 8m/sec
Acceleration is given as

$$a_c = \frac{v^2}{R}, \; a_t = 0$$

$$= \frac{8 \times 8}{0.4}$$

$$= 160 \text{ m/sec}^2$$

707. A particle moves in a circle of radius 5 m with a linear velocity of 25 ms^{-1}. Its angular velocity is _______.

(a) 5 rad. s^{-1} (b) 0.2 rad. s^{-1}
(c) 10 rad. s^{-1} (d) 0.1 rad. s^{-1}

AP EAMCET-07.09.2021, Shift-I

Ans. (a) : Given that, radius of circle (r) = 5m, linear velocity v = 25m/sec
We know that,

$$v = r\omega$$

$$\omega = \frac{v}{r}$$

$$\omega = \frac{25}{5}$$

$$\omega = 5 \text{ radian/sec} = 5 \text{ radian sec}^{-1}$$

708. If $\vec{\omega} = 3\hat{i} - 5\hat{j} + 2\hat{k}$ and $\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$, then find linear velocity _______.

(a) $-18\hat{i} - 8\hat{j} + 7\hat{k}$ (b) $-18\hat{i} - 13\hat{j} + 2\hat{k}$
(c) $4\hat{i} - 13\hat{j} + 6\hat{k}$ (d) $6\hat{i} - 2\hat{j} + 8\hat{k}$

AP EAMCET-07.09.2021, Shift-I

Ans. (a) : Given that, $\vec{\omega} = 3\hat{i} - 5\hat{j} + 2\hat{k}$
$\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$
The relation between linear velocity and angular velocity is–

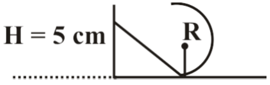
$$\vec{v} = \vec{\omega} \times \vec{r}$$

$$\vec{v} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -5 & 2 \\ 5 & -6 & 6 \end{vmatrix}$$

$$\vec{v} = \hat{i}(-30+12) - \hat{j}(18-10) + \hat{k}(-18+25)$$

$$\vec{v} = -18\hat{i} - 8\hat{j} + 7\hat{k}$$

709. Find the maximum radius of circle so that the block can complete the circular motion.



(a) 5 cm (b) 3 cm
(c) 2 cm (d) 4 cm

JIPMER-2019

Ans. (c) : According to the law of conservation of energy,
Loss in potential Energy = Gain in Kinetic Energy

$$mgH = \frac{1}{2}mv^2$$

$$v^2 = 2gH$$

$$\therefore \text{Velocity gained}(v) = \sqrt{2gH} \qquad \text{......(i)}$$

To complete the circular loop, minimum speed at bottom point, $V_{min} = \sqrt{5gR}$ .....(ii)

From equation (i) and (ii), we get

$$R_{max} = \frac{2H}{5} = \frac{2 \times 5}{5} = 2\text{cm}$$

710. When a body moves with a constant speed along a circle _______

(a) No acceleration is produced on the body
(b) No work is done on it
(c) Its velocity remains constant
(d) No force acts on the body

AP EAMCET-25.08.2021, Shift-II

Ans. (b) : There is no work done when speed is constant in circular motion as centripetal force is zero.

711. Assertion (A) : When a vehicle takes a turn on the road, it travels along a curved path.
Reason (R) : In a curved path, velocity of vehicle remains same.

(a) Both (A) and (R) true and (R) is the correct explanation of (A).
(b) Both (A) and (R) true and (R) is not the correct explanation of (A) .
(c) (A) is true, but (R) is not true.
(d) (A) is not true, but (R) is true.

AP EAMCET-25.04.2017, Shift-I

@apna_pdf

Ans. (c) : In curved path the frictional force acting thousands the center of the horizontal correct path provide the centripetal force and avoid overturning of vehicle. Due to the change in direction of motion, velocity changes in curved path.

So, Assertion is correct and reason is incorrect.

712. A car moves around a curved road of radius R_1 at constant speed v without sliding. If we double the car's speed, what is the least radius that would now keep the car from sliding?

(a) $2R_1$ (b) $4R_1$

(c) $6R_1$ (d) R_1

AMU-2013

Ans. (b) : A car can move around a curve road, If

$$v = \sqrt{\mu R_1 g} \quad .....(i)$$

According to the question, speed is doubled and radius is changed.

$$2v = \sqrt{\mu R_2 g} \quad .....(ii)$$

Dividing equation (i) and (ii), we get

$$\frac{1}{2} = \sqrt{\frac{R_1}{R_2}}$$

squaring on both side,

$$R_2 = 4R_1$$

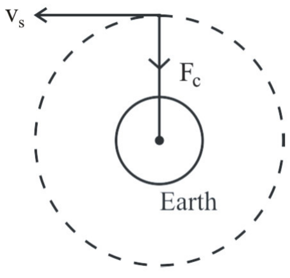
713. A cosmonaut is circling the earth in a satellite at 7 km/s at a height of 630 km above the surface of earth. Calculate the centripetal force acting on the cosmonaut if his mass is 80 kg (Take $R_E = 6.37 \times 10^6$ m)

(a) Zero (b) 560 N

(c) 600 N (d) 650 N

AMU-2012

Ans. (b) : Given, velocity (v_s) = 7 km/s, mass (m) = 80 kg, height (h) = 630 km



We know radius of earth (R) = 6370 km

$$R + h = 6370 + 630 = 7000\text{km}$$

$$R + h = 7 \times 10^6 \text{ m}$$

$$\text{Centripetal force } (F_c) = \frac{mv_s^2}{R}$$

$$F_c = \frac{80 \times (7000)^2}{7 \times 10^6}$$

$$F_c = 560\text{N}$$

714. A stone is tied to a string of length l and is whirled in a vertical circle with the other end of the string as the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of the change in velocity as it reaches a position where the string is horizontal (g being acceleration due to gravity) is

(a) $\sqrt{2(u^2 - g\ell)}$ (b) $\sqrt{u^2 - g\ell}$

(c) $u - \sqrt{u^2 - 2g\ell}$ (d) $\sqrt{2g\ell}$

AIPMT- 2004

Ans. (a) : By equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 = u^2 + 2 \times (-g) \times l \qquad \{\therefore a = -g, s = l\}$$

$$v = \sqrt{u^2 - 2gl}$$

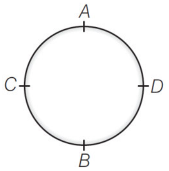
Change in velocity–

$$|\Delta v| = |v - u| = \sqrt{v^2 + u^2 - 2uv\cos 90^\circ}$$

$$= \sqrt{\left(\sqrt{u^2 - 2gl}\right)^2 + u^2 + 2u\left(\sqrt{u^2 - 2gl}\right) \times 0}$$

$$= \sqrt{u^2 - 2gl + u^2} = \sqrt{2(u^2 - gl)}$$

715. A stone is attached to one end of a string and rotated in a vertical circle. If string breaks at the position of maximum tension, then it will break at



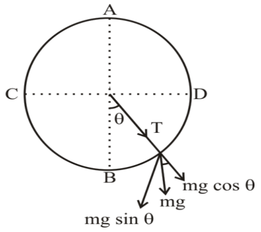
(a) A (b) B

(c) C (d) D

UP CPMT-2009

AIPMT- 2000

Ans. (b) : The body is describing a vertical circle



$$\therefore T - mg\cos\theta = \frac{mv^2}{l}$$

$$T = mg\cos\theta + \frac{mv^2}{l}$$

Tension is maximum when θ = 0° i.e. cos0° = 1 and velocity is maximum.

Both condition are satisfied at θ = 0° at lowest point B.

@apna_pdf

716. A ball of mass 0.25 kg attached to the end of a string of length 1.96m is moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which the ball can be moved?

(a) 14 m/s (b) 3 m/s
(c) 3.92 m/s (d) 5 m/s

AIPMT- 1998

Ans. (a) : Given,

$l = 1.96$ m
$T = 25$ N
$m = 0.25$ kg

Centrifugal force in the string is given by,

$$F = \frac{mv^2}{l}$$

The necessary centripetal force in the string is provided by the tension T in the string.

$$F = \frac{mv^2}{l}$$

$$25 = \frac{0.25 \times v^2}{1.96}$$

$$v = 14\,m/s.$$

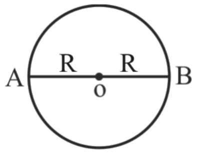
717. A Particle is moved in a semi-circular path of radius R. Then

(a) its average velocity is zero
(b) its average acceleration is zero
(c) its magnitude of displacement is 2R
(d) its average velocity and average speed are equal
(e) its distance travelled is equal to displacement

Kerala CEE 2020

Ans. (c) : When the body is completing half a revolution of a circular path of radius r then the: -
Distance traveled in half a rotation of a circular path is equal to the circumference of semi-circle $= \frac{2\pi R}{2} = \pi R$

- Displacement is known as the shortest distance between two points, as we can see the figure the shortest distance between point and point B is along the diameter of the circle thus displacement is 2r.



$R + R = 2R$

718. If an object undergoes a uniform circular motion, then its

(a) acceleration remains uniform
(b) velocity changes
(c) speed changes
(d) velocity remains uniform

NDA (I) 2013

Ans. (b) : The acceleration is related to the change in velocity either in magnitude (speed), or direction.

719. Motion of a particle can be described in x-direction by x = asinωt, and y-direction by y = bcosωt. The particle is moving on

(a) a circular path of radius 'a'
(b) a circular path of radius 'b'
(c) an elliptical path
(d) a straight line

NDA (II) 2013

Ans. (c) : Given that,
Motion of particle in x-direction,

$$x = a\sin(\omega t)$$

$$\frac{x}{a} = \sin\omega t \qquad ....(i)$$

And, motion of particle in y-direction,

$$y = b\cos\omega t$$

$$\frac{y}{b} = \cos\omega t \qquad ....(ii)$$

Squaring and adding both equation (i) and (ii),

$$\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = (\sin\omega t)^2 + (\cos\omega t)^2$$

$$\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = 1$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

This is the equation of ellipse.
Hence, the particle is moving on an elliptical path.

720. A body is just being revolved in a vertical circle of radius R with a uniform speed. The string breaks when the body is the highest point. The horizontal distance covered by the body after the string breaks is

(a) 2 R (b) R
(c) $R\sqrt{2}$ (d) 4R

MHT-CET-2020, 2006

Ans. (a) : Time taken by the body to reach the ground when string breaks,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times 2R}{g}} \qquad \{h = 2R\}$$

Hence, horizontal distance covered by the body

$$v_H \times t = \sqrt{gR} \times \sqrt{\frac{4R}{g}}$$

$$v_H \times t = \sqrt{4R^2}$$

$$v_H \times t = 2R$$

721. The acceleration of a body in a non-uniform circular motion is 5 ms^{-2}. Which one of the following is correct?

(a) The radial acceleration and the tangential accelerations are 3 ms^{-2} and 4 ms^{-2} respectively.
(b) The radial and the tangential accelerations are 2 ms^{-2} and 3 ms^{-2} respectively.

@apna_pdf

(c) The radial and the tangential accelerations are both 5 ms^{-2}.
(d) The radial and the tangential acceleration are 5 ms^{-2} and 3 ms^{-2} respectively.

AIIMS-2009

Ans. (a) : Given,

Acceleration of body $(a_r) = 3\ m/s^2$

tangential acceleration $(a_t) = 4\ m/s^2$

$$\therefore \quad a = \sqrt{a_t^2 + (a_r)^2}$$

$$a = \sqrt{(4)^2 + (3)^2} = \sqrt{25} = 5\,m/s^2$$

722. An object is moving in a circle at constant speed v. The magnitude of the rate of change of momentum of the object is

(a) zero
(b) proportional to v^2
(c) proportional to v^3
(d) proportional to v

CG PET- 2015
Manipal UGET - 2020

Ans. (b) : Rate of change of momentum of the object moving in circle.

$$\frac{\Delta p}{\Delta t} = F_{ext}$$

$$\frac{\Delta p}{\Delta t} = \frac{mv^2}{r} \qquad \left(\because F_{ext} = \frac{mv^2}{r}\right)$$

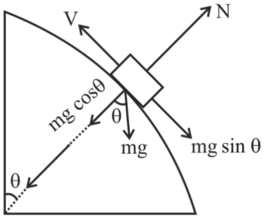
So, $$\frac{\Delta p}{\Delta t} \propto v^2$$

723. A motor cycle is going on an overbridge of radius R. The driver maintains a constant speed. As the motor cycle is ascending on the over bridge, the normal force on it

(a) Increases
(b) Decreases
(c) Remains the same
(d) Fluctuates erratically

JIPMER-2008

Ans. (a) : A motorcycle is going on an over bridge of radius R, then normal reaction is



$$N = mg\cos\theta - \frac{mv^2}{R}$$

When θ decreases then cosθ increase and normal force is also increase.

724. The minimum speed for a particle at the lowest point of a vertical circle of radius R, to describe the circle is v. If the radius of circle is reduced to one-fourth its value, the corresponding minimum speed will be

(a) $\frac{v}{4}$ (b) $\frac{v}{2}$
(c) 2 v (d) 4 v

EAMCET-1999

Ans. (b) : The minimum speed (v) of a particle at the lowest point is given by formula

$$v = \sqrt{5gR}$$

Where, g is the acceleration due to the gravity and R is the radius

Now,

For the first case Radius = R

And for the cases 2 Radius = R/4

Let the speed for the case 2 be v_2

Thus,

$$v_2 = \sqrt{5g\left(\frac{R}{4}\right)}$$

Or,

$$v_2 = \frac{1}{2}\sqrt{5gR} \qquad \text{........(i)}$$

Putting the value of $v = \sqrt{5gR}$ in equation (i)

$$v_2 = \frac{1}{2}v$$

$$\boxed{v_2 = \frac{v}{2}}$$

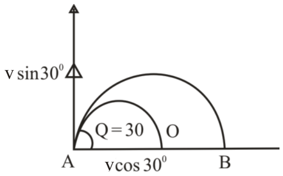
Hence, the value of the speed for Radius R/4 become half the value of speed for Radius R.

725. A player kicks a football at an angle 30° with the horizontal with an initial speed 30 ms^{-1}. A second player standing at a distance of $21\sqrt{3}$ m from the first and in the direction of kick, starts running to catch the ball, at the same instant as kicked by first player. The minimum speed of second player to catch the ball before it hits the ground is.

(Take acceleration due to gravity = 10ms^{-2})

(a) 10 ms^{-1} (b) 8 ms^{-1}
(c) $8\sqrt{3}$ ms^{-1} (d) $15\sqrt{3}ms^{-1}$

Ans. (c) : Let the ball be kicked from A and second player be at B ball and second player reach O at same time, t.



@apna_pdf

Therefore, $t=\dfrac{2u\sin\theta}{g}$

$$t=\frac{2\times30\sin30^{\circ}}{g}$$

$$t=\frac{2\times30\times\frac{1}{2}}{10}$$

$$t=\frac{30}{10}=3\,\text{sec}.$$

Range (R) $=\dfrac{u^2\sin2\theta}{g}$

$$R=\frac{(30)^2\sin60^{\circ}}{10}=\frac{900\times\frac{\sqrt{3}}{2}}{10}$$

$$R=45\sqrt{3}\,\text{m}$$

So, distance covered by 2^{nd} player is -

$d=45\sqrt{3}-21\sqrt{3}$

$d=24\sqrt{3}$

Now, speed of the second player–

$$v=\frac{d}{t}$$

$$v=\frac{24\sqrt{3}}{3}$$

$$v=8\sqrt{3}\,\text{m/sec}$$

726. A particle is moving with 10 m/s in a circle of radius 5m, find out magnitude of average velocity if particle moved by 60° in 1 sec.

(a) 5 m/s **(b) 10 m/s**

(c) $5\sqrt{3}$ m/s **(d) 20 m/s**

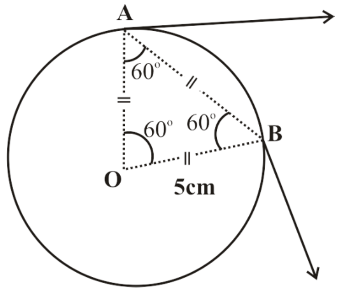
JIPMER-2019

Ans. (a): $\text{Average Velocity}=\dfrac{\text{Total displacement}}{\text{Total time}}$

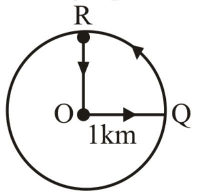
The displacement is equal to the radius of circle because the triangle is a equllateral triangle

$$\text{Average Velocity}==5\text{m/s}$$

$$=\frac{5}{1}=5\text{m/s}$$



727. A runner starts from O and goes to O following path OQRO in 1 hr. What is net displacement and average speed?

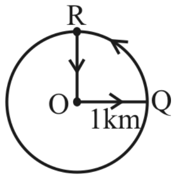


(a) 0,3.57 km/hr (b) 0,0 km/hr

(c) 0,2.57 km/hr (d) 0,1 km/hr

JIPMER-2018

Ans. (a) : For the given figure



Net displacement = 0

and average speed $=\dfrac{\text{Total distance}}{\text{Total time}}$

or average speed $=\dfrac{1\text{km}+\frac{\pi R}{2}+1\text{ km}}{1\text{hr}}$

$$=\frac{2\text{km}+\frac{3.14\times1}{2}}{1\text{hr}}\quad\begin{bmatrix}\text{radius}, R=1\text{km}\\ \pi=3.14\end{bmatrix}$$

i.e average speed = 3.57 km / hr

Hence option (a) is correct

728. An object moves in a circular path with a constant speed. Which one of the following statements is correct?

(a) The centripetal acceleration of the object is smaller for a gentle curve (i.e., curve of larger radius) than that for a sharp curve (i.e., curve of smaller radius).

(b) The centripetal acceleration is greater for a gentle curve than that for a sharp curve.

(c) The centripetal acceleration is the same for both, the gentle and sharp curves.

(d) The centripetal acceleration causes the object to slow down

NDA (II) 2017

Ans. (a): We know that the centripetal acceleration

$$a_c=\frac{v^2}{r}\qquad\text{where v is the velocity}$$

r, is the radius of the curve

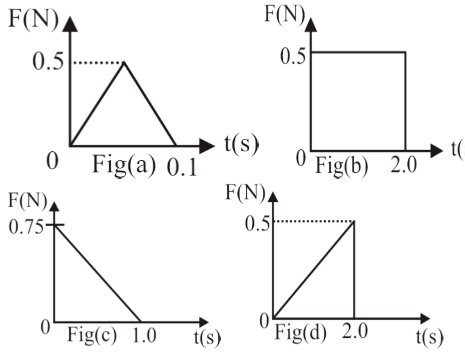
Speed is constant then radius has a bigger value in the case of gentle curve the centripetal acceleration will be smaller compared to a radius of smaller value.

@apna_pdf

04. Laws of Motion

(a) Momentum, Force and Inertia

1. Figure (a), (b), (c) and (d) show variation of force with time.



The impulse is highest in figure.

(a) Figure (b) (b) Figure (c)
(c) Figure (a) (d) Figure (d)

JEE Main-01.02.2023, Shift-II

Ans. (a) : Impulse (I) = Area under F – t curve

For option (a),

$$\text{Area} = \frac{1}{2}\times 0.1\times 0.5 = \frac{0.05}{2} = 0.025$$

$$\text{Impulse } (I_A) = 0.025\text{N.s}$$

For option (b),

$$\text{Area} = 0.5 \times 2 = 1$$

$$\text{Impulse } (I_B) = 1 \text{ N.s}$$

For option (c),

$$\text{Area} = \frac{1}{2} \times 0.75 \times 1 = 0.375$$

$$\text{Impulse } (I_c) = 0.375 \text{ N.s}$$

For option (d),

$$\text{Area} = \frac{1}{2} \times 2 \times 0.5 = 0.5$$

$$\text{Impulse } (I_D) = 0.5 \text{ N.s}$$

Hence, the impulse is highest in figure (b).

2. Two masses of 1 g and 4 g are moving with equal kinetic energy. The ratio of the magnitudes of their linear momentum is

(a) 4 : 1 (b) 1 : 2
(c) $\sqrt{2}$: 1 (d) 1 : 16

TS EAMCET 28.09.2020, Shift-I
UPSEE-2008
AIPMT-1993

Ans. (b) : Given that,

Mass of bodies, m_1=1kg

m_2 = 4kg

Both kinetic energy are equal

$$\text{Kinetic energy (K)} = \frac{P^2}{2m}$$

$$P = \sqrt{2mK}$$

According to question kinetic energy is same.

So, $P \propto \sqrt{m}$

$$\therefore \quad \frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$$

$$= \sqrt{\frac{1}{4}}$$

$$\frac{P_1}{P_2} = \frac{1}{2}$$

P_1:P_2=1:2

3. Two bodies of masses m and 4 m have kinetic energies in the ratio 1:2. Their momentum p_1 and p_2 are in the ratio

(a) $1:2\sqrt{2}$ (b) $1:2\sqrt{3}$
(c) $2\sqrt{2}:1$ (d) $3\sqrt{2}:1$
(e) $1:3\sqrt{2}$

Kerala CEE 04.07.2022

Ans. (a) : Given,

$$m_1 = m, \quad \frac{(K.E.)_1}{(K.E.)_2} = \frac{1}{2}$$
$$m_2 = 4m$$

$$\frac{P_1}{P_2} = ?$$

We know that,

$$K.E = \frac{P^2}{2m}$$

$$K.E \propto \frac{P^2}{m}$$

$$\frac{(K.E)_1}{(K.E)_2} = \left(\frac{P_1}{P_2}\right)^2\left(\frac{m_2}{m_1}\right)$$

$$\frac{1}{2} = \left(\frac{P_1}{P_2}\right)^2\left(\frac{4m}{m}\right)$$

$$\frac{1}{2} = \left(\frac{P_1}{P_2}\right)^2(4)$$

$$\frac{1}{8} = \left(\frac{P_1}{P_2}\right)^2$$

$$\frac{P_1}{P_2} = \frac{1}{2\sqrt{2}}$$

4. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1}. The impulse imparted to the ball is ———— Ns

JEE Main-26.06.2022, Shift-II

@apna_pdf

Ans. (12) : Given data,

Mass, (m) = 0.4 kg

Initial speed, (u) = 150 ms^{-1}

Impulse, [J] = ?

We know that,

$J = \Delta p$

$J = p_f - p_i$

$J = mv - (-mv)$

$J = 2\ mv$

$J = 2 \times 0.4 \times 15$

$J = 12$ N-s

5. A body of mass 2 kg moves with an acceleration 3 ms^{-2}. The change in momentum in one second is:

(a) $\frac{2}{3}\text{kg m s}^{-1}$ (b) $\frac{3}{2}\text{kg m s}^{-1}$

(c) 6kg m s^{-1} (d) 5 kg m s^{-1}

AP EAMCET-06.09.2021, Shift-I

Ans. (c) : Given that,

Mass of the body (m) = 2 kg

Acceleration of the body (a) = 3m/sec^2

By Newton's second law

Rate of change of momentum is equal to applied force

$$F = \frac{dp}{dt}$$

$$\int_0^1 F dt = \int_{P_1}^{P_2} dp$$

$$F\int_0^1 dt = \int_{P_1}^{P_2} dp$$

$$F[t]_0^1 = [p]_{p_1}^{p_2}$$

$$F(1-0) = p_2 - p_1$$

$$F = \Delta p \quad \text{.... (i)}$$

$\because$ F = ma

F = 2 × 3

F = 6 N

$\therefore$ $\Delta p = 6$ kg m s^{-1} {from (i)}

So, change of momentum in one second is 6 kg ms^{-1}

6. Area under the force-time graph gives the change in

(a) velocity

(b) acceleration

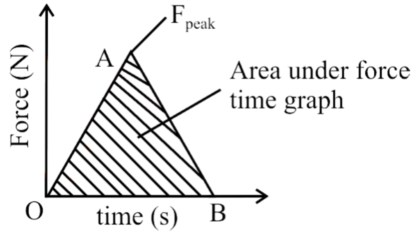
(c) linear momentum

(d) angular momentum

(e) impulsive force

Kerala CEE 2021

Ans. (e) :



If we calculate area of triangle OAB,

Area of shaped portion,

$$= \frac{1}{2} \times \text{Base} \times \text{Altitude}$$

$$= \frac{1}{2} \times \text{time} \times F_{peak}$$

The above term gives impulse or change in momentum of body.

Hence, Area under the force-time graph gives the impulse or change in momentum acting on the body.

7. A ball of mass 0.15 kg is dropped from a height 10 m, strikes the ground and rebounds to the same height. The magnitude of impulse imparted to the ball is nearly (g = 10 m/s^2)

(a) 0 (b) 4.2 kg-m/s

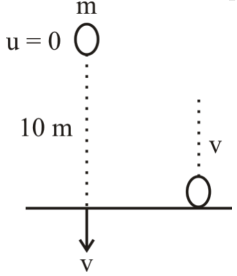
(c) 2.1 kg-m/s (d) 1.4 kg-m/s

NEET- 2021

Ans. (b) : Given,

Mass of the ball = 0.15 kg

Height from which ball is dropped = 10 m



We know that,

Impulse, I = change in linear momentum (Δp)

Velocity of ball at ground, $v = \sqrt{2gh}$

$v = \sqrt{2 \times 10 \times 10}$

$v = 10\sqrt{2}$ m/s

$I = \Delta p$

$= mv_f - mv_i = mv - [m(-v)] = 2\ mv$

$= 2 \times 0.15 \times 10\sqrt{2} = 4.2$ kg-m/s

8. Which of the following statement is correct?

(a) Electromagnetic force is short ranged

(b) Relative strength of gravitational force is higher than that of weak nuclear force

(c) Range of the weak nuclear force is smaller than that of strong nuclear force

(d) Relative strength of strong nuclear force may or may not be higher than that of electromagnetic force

TS EAMCET 05.08.2021, Shift-II

Ans. (c) : Relative strength and range of forces

Force	Approximate Relative Strengths	Range
Gravitational	10^{-38}	∞
Electromagnetic	10^{-2}	∞
Weak nuclear	10^{-13}	$< 10^{-18}$ m
Strong nuclear	1	$< 10^{-15}$ m

$\therefore$ Range of the weak nuclear force is smaller than that of strong nuclear force is correct.

@apna_pdf

9. Two bodies having masses in the ratio 2 : 3 fall freely under gravity from heights which are in the ratio 9 : 16. The ratio of their linear momentum on touching the ground is _______.

(a) 2 : 9 (b) 3 : 16
(c) 1 : 2 (d) 3 : 2

AP EAMCET-25.08.2021, Shift-I

Ans. (c) : Given,

$m_1 : m_2 = 2 : 3$

$h_1 : h_2 = 9 : 16$

Linear momentum, P = mv

$v^2 = u^2 + 2gh$

$v = \sqrt{2gh}$ $\{\because \text{initial velocity, } u = 0\}$

$P = m\sqrt{2gh}$

$P \propto m\sqrt{h}$

The ratio of their linear momentum,

$$\left(\frac{P_1}{P_2}\right) = \left(\frac{m_1}{m_2}\right).\sqrt{\frac{h_1}{h_2}}$$

$$\frac{P_1}{P_2} = \frac{2}{3}\times\sqrt{\frac{9}{16}} = \frac{2}{3}\times\frac{3}{4} = \frac{1}{2}$$

$P_1 : P_2 = 1 : 2$

10. A force acts on a body of mass 50 kg, for 10 seconds. When the force stops acting on the body, the body covers 80 m in the next 10 seconds. What is the magnitude of the force?

(a) 40 N (b) 50 N
(c) 30 N (d) 60 N

AP EAMCET-03.09.2021, Shift-I

Ans. (a) : Given data-

Mass of body (m)= 50 kg

Time (t) = 10 seconds

Displacement (Δs)= 80 m

Force (F)= ?

We know that,

$$\text{Velocity} = \frac{\Delta s}{t} = \frac{80}{10} = 8 \text{ m/sec}$$

$$\text{Then, acceleration (a)} = \frac{v}{t} = \frac{8}{10}$$

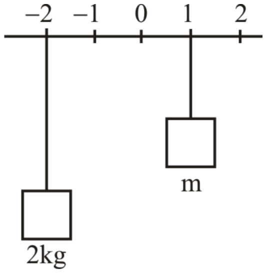
$$= 0.8 \text{ m/sec}^2$$

So, Force (F)= ma

F= 50×0.8

F= 40N

11. A horizontal beam is pivoted at 0 as shown in the figure. What should be the value of mass 'm' to maintain the beam in horizontal position?



(a) 2 kg (b) 1 kg
(c) 4 kg (d) 2.5 kg

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (c) : Take moment about 0,

$m_1 g\, x_1 = m_2 g\, x_2$

$2 \times g \times 2 = m \times g \times 1$

$m = 4$ kg

12. Which of the following is NOT a fundamental force in nature?

(a) Weak nuclear Force (b) Gravity
(c) Friction (d) Electromagnetic

TS EAMCET 06.08.2021, Shift-II

Ans. (c) : ⇒ The four fundamental forces in nature are as

i) Gravitational force
ii) Electromagnetic force
iii) Strong nuclear force
iv) Weak nuclear force

Among the given forces, friction is not a fundamental force in nature.

13. A physical quantity A on multiplication with velocity results in another quantity B. If the quantity B is energy, then the quantity A is

(a) mass (b) momentum
(c) force (d) acceleration
(e) Power

Kerala CEE 2021

Ans. (b) : According to given question,

A × Velocity = Energy

$$A \times v = \frac{1}{2}mv^2 \qquad \left\{\text{Energy} = \frac{1}{2}mv^2\right\}$$

$$A = \frac{1}{2}mv$$

$$A = \frac{p}{2} \qquad \{p = mv\}$$

p = momentum

14. A body of mass 10 kg has constant velocity of 10 ms^{-1}. A constant force is applied for a duration of 4s on the object and gives it a speed of 2 ms^{-1} in opposite direction. Then, find acceleration produced in it.

(a) 3 ms^{-2} (b) –3 ms^{-2}
(c) 0.3 ms^{-2} (d) –0.3 ms^{-2}

AP EAMCET (17.09.2020) Shift-II

Ans. (b) : Given,

$v_i = 10$ m/s

m = 10 kg

$v_f = -2$ m/s (opposite direction)

t = 4s

Then acceleration ,

$$\therefore \quad a = \frac{v_f - v_i}{t}$$

$$a = \frac{-2-10}{4}$$

$$a = \frac{-12}{4}$$

$a = -3$ m/s^2

@apna_pdf

15. Five objects of different masses are simultaneously released vertically downwards from height 'h' (in air). Which physical quantity associated with the objects will change at the instant they strike the ground? (neglect the air resistance.)

(a) Time (b) Momentum
(c) Velocity (d) Acceleration

MHT-CET 2020

Ans. (b) : We know that,

$$\text{height (h)} = \frac{1}{2}gt^2$$

So, $$t = \sqrt{\frac{2h}{g}}$$

Time is same for all objects. (Given)

$$v = gt$$

Velocity is also same for all objects

Mass of objects are different so momentum (P=mv) are different for objects.

So, momentum p will be different for all.

16. A force of 0.03 N acts on a body of mass 0.5 kg. which is initially at rest for a duration of 10 seconds. Then find the momentum acquired by the body.

(a) 0.15 kg. m.s^{-1} (b) 0.3 kg. m.s^{-1}
(c) 0.015 kg. m.s^{-1} (d) 0.05 kg. m.s^{-1}

AP EAMCET-24.09.2020, Shift-I

Ans. (b) : Given,

Force, F = 0.03 N
Mass, m = 0.5 kg
Time, t = 10 sec
Initial velocity, u = 0
F = ma

$$\text{acceleration, } a = \frac{0.03}{0.5} = 0.06\ m/s^2$$

Now, $v = u + at$
$v = 0 + 0.06 \times 10$
$v = 0.6$ m/s

So, momentum P = mv
$P = 0.5 \times 0.6$
P = 0.3 kg.m/s

17. A bullet of mass 20g moving with a velocity of 200 m/s strikes a target and is brought to rest in $\left(\frac{1}{50}\right)^{th}$ of a second. The impulse and average force of impact are respectively.

(a) 2 Ns, 100 N (b) 4 Ns, 200 N
(c) 2 Ns, 200 N (d) 4 Ns, 100 N

MHT-CET 2020

Ans. (b) : Given, m = 20 g, v = 200 m/s

momentum (p) = mv

$p = 20 \times 10^{-3}$ kg × 200 m/s

p = 4 kg m/s

Impulse = change in momentum (p) = 4 kg m/s
= 4 Ns

$$\therefore \text{Force} = \frac{\text{Impulse}}{\text{Time}}$$

$$F = \frac{4}{\left(\frac{1}{50}\right)} = 200\text{N}$$

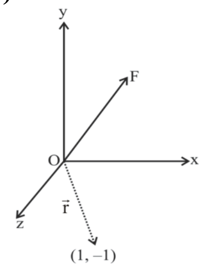
The impulse and average force of impact are respectively 4Ns, 200N.

18. Let a force $\vec{F} = -F\hat{k}$ acts on the origin of Cartesian frame of reference. The moment of force about a point (1, -1) will be

(a) $F(\hat{i}-\hat{j})$ (b) $F(\hat{i}+\hat{j})$
(c) $-F(\hat{i}-\hat{j})$ (d) $-F(\hat{i}+\hat{j})$

MHT-CET 2020

Ans. (b) :



The torque about the given position, $\tau = \vec{r} \times F$

Here, $\vec{r} = \hat{i} - \hat{j}$ and $F = -F\hat{k}$

$$\therefore \quad \tau = \left(\hat{i}-\hat{j}\right) \times (-F\hat{k})$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 0 \\ 0 & 0 & -F \end{vmatrix} = F\hat{i} - \hat{j}(-F)$$

$$\tau = F\left(\hat{i}+\hat{j}\right)$$

19. A body of mass 2kg is acted upon by two perpendicular forces 4N and 3N. The magnitude and direction of the acceleration of the body respectively are.

(a) $2.5\,m/s^2.\text{Tan}^{-1}\left(\frac{3}{4}\right)$ with respect to the direction of 4N force

(b) $2.5\,m/s^2.\text{Tan}^{-1}\left(\frac{3}{4}\right)$ with respect to the direction of 3N force

(c) $2.0\,m/s^2.\text{Tan}^{-1}\left(\frac{4}{3}\right)$ with respect to the direction of 4N force

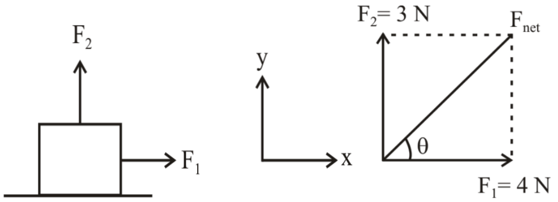
(d) $2.0\,m/s^2.\text{Tan}^{-1}\left(\frac{3}{4}\right)$ with respect to the direction of 3N force

TS EAMCET 28.09.2020, Shift-II

Ans. (a) : Given that

mass of body (m) = 2 kg
two perpendicular forces = 4N, 3N

@apna_pdf



$$F_{net} = \sqrt{4^2+3^2}$$
$$= 5\text{ N}$$
$\therefore$ $F_{net} = ma$
$5 = 2.a \Rightarrow a = 2.5\text{ m/sec}^2$
direction of resultant

$$\tan\theta = \frac{F_2}{F_1}$$

$$\tan\theta = \frac{3}{4}$$

$$\theta = \tan^{-1}\left(\frac{3}{4}\right)$$

20. The resultant force of 5 N and 10 N cannot be __________

(a) 12 N (b) 4 N
(c) 8 N (d) 5 N

AP EAMCET (Medical)-07.10.2020, Shift-I

Ans. (b) : The resultant force of 5N and 10N,
$F_{max} = 10 + 5$
$F_{max} = 15$ N
$F_{min} = 10 - 5$
$F_{min} = 5$ N
Range of force = $5 \le F \le 15$
Hence, option (b) is correct.

21. A batsman hits a ball of mass 0.2 kg straight towards the bowler without changing its initial speed of 6 m/s. What is the impulse imparted to the ball?

(a) 3.2 Ns (b) 2.4 Ns
(c) 1.6 Ns (d) 4 Ns

MHT-CET 2020

Ans. (b) : We know that change in momentum equal to impulse
$p_i = mv$

$p_f = -mv$
$|\Delta p| = mv - (-mv) = 2\text{ mv}$
$= 2 \times 0.2 \times 6 = 2.4$ Ns

22. Find the apparent weight of a body of mass, 1.0 kg falling with an acceleration of 10 ms^{-2}. (g ≈ 10 ms^{-2})

(a) 1 kg-wt (b) 2 kg-wt
(c) 0 (d) 0.5 kg-wt

AP EAMCET (18.09.2020) Shift-I

Ans. (c) : Given, mass (m) = 1 kg, acceleration (a) = 10 m/s^2, g = 10 m/s^2
As the body is falling so using second law of motion
$mg - N = ma$
$N = m(g - a)$
$N = 1(10-10)$
$N = 0$

23. A force of 10 N acts on a body of mass 0.5 kg for 0.25s starting from rest. What is its momentum now?

(a) 0.25 N-s (b) 2.5 N-s
(c) 0.5 N-s (d) 0.75 N-s

JIPMER-2018

Ans. (b) : Given, F = 10 N, m = 0.5 kg and t = 0.25 sec
We know that,
Momentum (p) = mv …(i)
Then,
Force (F) = ma

$$\text{Acceleration}\,(a) = \frac{F}{m} = \frac{10}{0.5} = 20\,\text{m/s}^2$$

From the Newton's first law of motion
$\therefore$ $v = u + at$
$= 0 + 20 \times 0.25 = 5$ m/s
Then, from equation (i)
$p = 0.5 \times 5 = 2.5$ N-s

24. A man throws a ball of mass 3.0 kg with a speed of 5.0 ms^{-1}. His hand is in contact with the ball for 0.2 s. If the throws 4 balls in 2 seconds, the average force exerted by him in 1 second is

(a) 15 N (b) 30 N
(c) 150 N (d) 75 N

AMU-2018

Ans. (b) : Given,
Mass of the ball (m) = 3 kg
Speed (v) = 5 m/s
Time taken by the man to throw a ball is,

$$\Delta t = \frac{2}{4} = 0.5\,\text{s}$$

Change in momentum of the ball = Mass × Speed
= m.v
= 3 × 5
= 15 Ns
Force = Rate of change in linear momentum

$$F = \frac{\Delta p}{\Delta t} = \frac{15}{0.5} = 30\,\text{N}$$

25. When a train takes a turn, the passengers are thrown outwards because of–

(a) acceleration of motion
(b) speed of motion
(c) inertia of direction
(d) Both (a) and (c)

BCECE-2018

Ans. (c) : Law of inertia states that, everybody continues to be in its state of rest or of uniform motion in a straight line unless compelled by some external force.
There are three types of inertia–
1. Inertia of rest
2. Inertia of motion
3. Inertia of direction
In this question third type of inertia that causes the passengers to be thrown outwards when the driver makes sudden turn.

26. Which one of following is a characteristic of force?

(a) can make a stationary object to start move.
(b) cannot make a moving object to increase speed.

@apna_pdf

(c) can make a moving object to decrease speed.
(d) can change direction of an object.

SRM JEE-2018

Ans. (b) : Force characteristics–

- It is a product of the interaction between two objects
- It may change the state of motion.
- It can also alter the direction of a moving object.
- It is a vector quantity, which means it has both magnitude and direction.
- It may change the shape of the object.

27. Two forces of magnitude 5 N and 10 N act on a wooden block of mass 2 kg. If 5 N force acts towards right and 10N force acts towards left, which one of the following statements is correct?

(a) Resultant force is 15 N towards left.
(b) Resultant force is 15 N towards right.
(c) Resultant force is 5 N towards right.
(d) Resultant force is 5 N towards left.

SRMJEEE-2017

Ans. (d) : Two forces of magnitudes, 5 N and 10 N act on body

Letm, P = 5 N, Q = 15 N

$$10\,\text{N} \longleftarrow \boxed{2\text{kg}} \longrightarrow 5\text{N}$$

$$F_{net} = 5\text{ N} - 10\text{ N} = -5\text{ N}$$

Resultant force is 5 N toward left.

28. The two factors on which the momentum of a body depends are ____ and ____.

(a) Velocity, time
(b) Mass, weight
(c) Mass, distance
(d) Mass, velocity

SRMJEEE-2017

Ans. (d) : The momentum of a body is the product of the mass of the body and the velocity of the body.

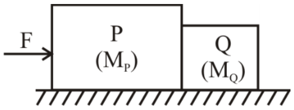
The mathematical representation of the momentum of a body is

$$p = mv$$

Where, p = momentum
m = mass
v = velocity

Here, momentum is directly proportional to the mass and velocity of the body.

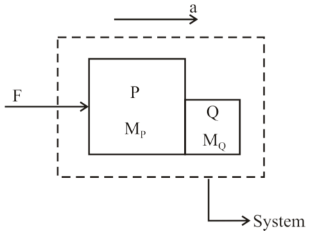
29. A block P of mass M_P is in contact with another block Q of mass M_Q as shown in the figure and they are placed on a smooth floor. Force on block Q is



(a) $\frac{M_P}{M_P+M_Q}$
(b) $\frac{M_QF}{M_P+M_Q}$
(c) $\frac{M_PF}{M_Q}$
(d) $\frac{M_QF}{M_P}$

VITEEE - 2017
AP EAMCET (22.09.2020) Shift-I

Ans. (b) : Given, mass of block P = M_P, mass of block Q = M_Q

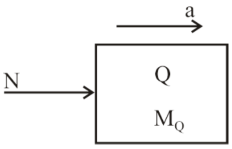


Since, $F_{ext} = ma$

$$F = (M_P + M_Q)a$$

$$a = \frac{F}{M_P + M_Q}$$

Now,



$$\therefore \quad N = M_Q a$$

Put the value of 'a'

$$N = \frac{M_QF}{M_P + M_Q}$$

30. The momentum of the particle at any instant is given by $3\cos 4t\,\hat{i} + 3\sin 4t\,\hat{j}$. What is the angle between momentum and force acting on it?

(a) 60°
(b) 30°
(c) 45°
(d) 90°

J&K CET- 2005
AP EAMCET- 23.09.2020 Shift-II

Ans. (d) : Given,

$$\vec{p} = 3\cos 4t\hat{i} + 3\sin 4t\hat{j}$$

$$\text{Force} = \frac{d\vec{p}}{dt} = \frac{d}{dt}\left(3\cos 4t\hat{i} + 3\sin 4t\hat{j}\right)$$

$$\vec{F} = -12\sin 4t\hat{i} + 12\cos 4t\hat{j}$$

$$\vec{F}.\vec{P} = |\vec{F}|.|\vec{P}|\cos\theta$$

$$|\vec{F}|.|\vec{P}|\cos\theta = \left(-12\sin 4t\hat{i} + 12\cos 4t\hat{j}\right)\left(3\cos 4t\hat{i} + 3\sin 4t\hat{j}\right)$$

$$|\vec{F}|.|\vec{P}|\cos\theta = 36\left(-\sin 4t\cos 4t + \cos 4t\sin 4t\right)$$

$$|\vec{F}|.|\vec{P}|\cos\theta = 36\,[\sin(4t-4t)]$$

$$|\vec{F}|.|\vec{P}|\cos\theta = 0$$

$$\cos\theta = \cos 90^\circ$$

$$\theta = 90^\circ$$

31. A reference frame attached to earth cannot be an inertial frame because

(a) Earth is revolving around the sun
(b) Earth is rotating about its axis
(c) Newton's laws are applicable in this frame
(d) both (a) and (b)

JCECE-2007
BITSAT-2008

@apna_pdf

Ans. (d) : A reference frame in which the observers are not subjected to any accelerating force is know inertial frame.

Force will act on earth whether it is revolving about its own axis or around sun. This force will cause acceleration on earth.

Hence, Earth is not an inertial frame of reference.

32. A machine gun of mass 10 kg fires 30 g bullets at the rate of 6 bullet/s with a speed of 400 m/s. The force required to keep the gun in position will be

(a) 30 N
(b) 40 N
(c) 72 N
(d) 400 N

JCECE-2013

Ans. (c) : Given that, 10 kg & 30×10^{-3} kg mass of machine gun and bullet respectively & 6 bullet/s fired

Let v be the velocity of each unit,

According to conservation of momentum

$$m_1 \times v = m_2 \times 400$$

$$10 \times v = 6 \times 30 \times 10^{-3} \times 400$$

$$\therefore \quad v = \frac{12 \times 6}{10} = 7.2 \text{ m/s}$$

$$= \frac{\Delta P}{\Delta t} \qquad [\because \Delta t = 1 \text{ sec}]$$

$$= \frac{m_1 v}{1} = \frac{10 \times 7.2}{1} = 72\text{N} = 72 \text{ N}$$

33. A ball of mass 0.5 kg moving with a velocity of 2 m/sec strikes a wall normally and bounces back with the same speed. If the time of contact between the ball and the wall is one millisecond, the average force exerted by the wall on the ball is:

(a) 2000 newton
(b) 1000 newton
(c) 5000 newton
(d) 125 newton

AIIMS-2015

Ans. (a) : Given,

mass = 0.5 kg

initial velocity (v_i) = 2 m/s

final velocity (v_f) = –2 m/s

time of contact (t) = 1 millisecond = 10^{-3} sec

$$F_{\text{exerted}} = \frac{\Delta p}{\Delta t} = \frac{mv_f - mv_i}{t}$$

$$= \frac{0.5 \times (-2) - 0.5 \times 2}{10^{-3}} = -2 \times 10^3 \text{N}$$

$|F_{\text{exerted}}|$ = 2000 N

34. If the force on a rocket, moving with a velocity 500 m/s is 400 N, then the rate of combustion of the fuel will be:

(a) 0.8 kg/sec
(b) 10.8 kg/sec
(c) 8 kg/sec
(d) 1.6 kg/sec

AIIMS-1997

Ans. (a) : Given, velocity of rocket (v) = 500 m/s

Force = 400 N

Fuel is continuously combusting hence mass of rocket changes continuously then rate of change of mass of Rocket = Rate of combustion of fuel $\left(\frac{dm}{dt}\right)$ = ?

$$\therefore \quad F = \frac{vdm}{dt}$$

$$\frac{F}{v} = \frac{dm}{dt}$$

$$\frac{400}{500} = \frac{dm}{dt}$$

$$\frac{dm}{dt} = 0.8 \text{ kg/sec}$$

Hence, rate of combustion of fuel = 0.8 kg/sec

35. The linear momentum p of a body varies with times as p = α + βt² where α and β are constants. The net force action on the body for one dimensional motion varies as

(a) t^2
(b) t^{-1}
(c) t^{-2}
(d) t

SCRA-2012
AMU-2004

Ans. (d) : Given,

Momentum (p) = $\alpha + \beta t^2$

We know force in terms of momentum

$$\text{Force (F)} = \frac{dp}{dt}$$

$$F = \frac{d(\alpha + \beta t^2)}{dt}$$

$$F = 2\beta t$$

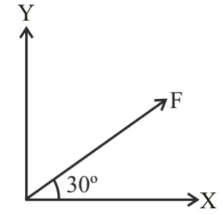
$$F \propto t$$

36. The X and Y components of a force F acting at 30° to x-axis are respectively:

(a) $F, \frac{F}{\sqrt{2}}$
(b) $\frac{F}{\sqrt{2}}, F$
(c) $\frac{F}{2}, \frac{\sqrt{3}}{2}F$
(d) $\frac{\sqrt{3}}{2}F, \frac{1}{2}F$

Karnataka CET-2012

Ans. (d) :



The X component of force (F) is

$$F_X = F \cos 30°$$

$$F_X = F \times \frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2} F$$

The Y component of force 'F' is

$$F_Y = F \sin 30° = F \times \frac{1}{2} = \frac{F}{2}$$

37. A batsman hits back a ball straight in the direction of the bowler without changing its initial speed of 12 m/s. If the mass of the ball is 0.15 kg the impulse imparted to the ball is

(a) 36 N s
(b) 3.6 N s
(c) 0.36 N s
(d) 0.036 N s

J&K CET- 2011

@apna_pdf

Ans. (b) : Given,

Initial velocity (v_i) = 12 m/s

Final velocity (v_f) = –12 m/s

and mass (m) = 0.15 kg

Initial momentum $(p_i) = mv_i = 0.15 \times 12 = 1.8\ \text{kgm/sec}$

Final momentum $(p_f) = mv_f$

$= 0.15 \times (-12) = -1.8\ \text{kgm/s}$

Change in momentum $\Delta p = p_f - p_i$

$= -1.8 - 1.8$

$= -3.6$ kg m/s

$|\Delta p| = 3.6\ \text{kgms}^{-1}$

Then, Impulse (I) = $|\Delta p|$

I = 3.6 Ns

38. Assuming earth to be an inertial frame, an example for inertial frame observer is

(a) a driver in a train which is slowing down to stop
(b) a person in a car moving with uniform velocity
(c) a girl revolving in a merry-go round
(d) a passenger in an aircraft which is taking off.

J&K CET- 2009

Ans. (b) : An inertial frame of reference is a frame where Newton's law holds true. That means if no external force is acting on a body it will stay at rest or remain in uniform motion.

Hence, a person in a car moving with uniform velocity is an example of inertial frame because in uniform velocity acceleration is zero.

39. A cricket ball of mass 0.5 kg strikes a cricket bat normally with a velocity of 20 m s^{-1} and rebounds with a velocity of 10 m s^{-1}. The impulse of the force exerted by the ball on the bat is

(a) 15 N s (b) 25 N s
(c) 30 N s (d) 10 N s

J&K CET- 2009

Ans. (a) : Given mass =0.5 kg

Initial velocity (v_i) = 20 m/s

Final velocity (v_f) = –10 m/s

Change in momentum $(\Delta p) = mv_f - mv_i$

$\therefore \quad \Delta p = 0.5 \times (-10) - 0.5 \times 20$

$\Delta p = -0.5(10+20)$

$\Delta p = -0.5 \times 30$

$\Delta p = -15\ \text{N}$

$\therefore$ Impulse I = $|\Delta p|$

= 15 Ns

40. The rate of mass of the gas emitted from rear of a rocket is initially 0.1 kg/sec. If the speed of the gas relative to the rocket is 50 m/sec and mass of the rocket is 2 kg, then the acceleration of the rocket in m/sec^2 is

(a) 5 (b) 5.2
(c) 2.5 (d) 25

J&K CET- 2008

Ans. (c) : Rate of mass of gas $\left(\dfrac{dm}{dt}\right) = 0.1\ \text{kg/sec}$

Speed of gas relative to rocket (V_{gR}) = 50 m/s

Mass of Rocket (m) = 2 kg

We know that,

$$F = \frac{dm}{dt} V_{gR}$$

$$F = 0.1 \times 50$$

$$F = 5\ \text{N}$$

Then we know,

$$F = ma$$

$$a = \frac{F}{m} = \frac{5}{2}$$

$$a = 2.5\ \text{m/s}^2$$

41. A gun fires N bullets per second, each of mass m with velocity v. The force exerted by the bullets on the gun is

(a) vNm (b) $\dfrac{mv}{N}$
(c) mvN^2 (d) $\dfrac{mv^2}{N}$

J&K CET- 2008

Ans. (a) : Initial velocity of Bullet (v_i) = 0

Final velocity (v_f) = Nv

and t = 1 sec

Change in momentum (Δp) = ($p_f - p_i$) = m($v_f - v_i$)

= m(Nv – 0)

(Δp) = Nmv

Then, $F = \dfrac{\Delta p}{\Delta t} = \dfrac{Nmv}{1} = Nmv$

42. A body of mass 10 kg is acted by two forces each of magnitude 10 N making an angle of 60° with each other. Find the net acceleration of the body is

(a) $2\sqrt{3}$ m/s^2 (b) $\sqrt{3}$ m/s^2
(c) $3\sqrt{3}$ m/s^2 (d) $4\sqrt{3}$ m/s^2

J&K CET- 2007

Ans. (b) : Given mass (m) = 10 kg, $F_1 = F_2$ = 10 N and $\theta = 60°$

$$F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{(10)^2 + (10)^2 + 2 \times 10 \times 10 \cos 60°}$$

$$= \sqrt{100 + 100 + 100}$$

$$= 10\sqrt{3}$$

We know, $F = ma \Rightarrow a = \dfrac{F}{m}$

$$a = \frac{10\sqrt{3}}{10}$$

Acceleration (a) = $\sqrt{3}\ \text{m/s}^2$

43. Impulse is

(a) a scalar
(b) equal to change in the momentum of a body
(c) equal to rate of change of momentum of a body

@apna_pdf

(d) a force

J&K CET- 2006

Ans. (b) : Impulse is equal to change in the momentum of a body.

$$I = \Delta P = F.\Delta t$$

44. Which of the following is a self adjusting force?

(a) Static friction (b) Limiting friction
(c) Dynamic friction (d) Sliding friction

J&K CET- 1999

Ans. (a) : Static friction is a force that keeps an object at rest. It is a self adjusting force because it does not have any fixed magnitude, but will adjust itself according to the applied force, till it reaches its optimum value.

45. An object is moving at constant velocity. The total force F acting on the object is given by

(a) $F = v^2/2m$ (b) $F = mv$
(c) $F = 0$ (d) $F = mv^2$

J&K CET- 1997

Ans. (c) : Since the object is moving with a constant velocity. It means an acceleration of the body will be zero. So the net force on the object will be zero (i.e. F = 0).

46. The net force acting is not zero on

(a) a retarding train
(b) a ball falling with terminal velocity
(c) a kite held stationary
(d) a truck moving with constant velocity
(e) a book placed on a table

KERALA CEE - 2016

Ans. (a) : The net force acting is not zero, then there is deceleration (retardation) or a negative acceleration.

47. Which one of the following is not a contact force?

(a) Viscous force (b) Air resistance
(c) Friction (d) Buoyant force
(e) Magnetic force

KERALA CEE - 2010

Ans. (e) : Contact force acts at the point at which two objects come into contact with each other.
∴ Magnetic force is not a contact force.

48. A 10 N force is applied on a body produces an acceleration of 1m/s^2. The mass of the body is

(a) 5 kg (b) 10 kg
(c) 15 kg (d) 20 kg

AIPMT- 1996

Ans. (b) : Given that,
Force, F = 10N
Acceleration, a = 1 m/s^2

$$F = ma$$
$$10 = m \times 1$$
$$m = 10 \text{ kg}$$

49. A body, under the action of a force $F = 6\hat{i} - 8\hat{j} + 10\hat{k}$, acquires an acceleration of 1 ms^{-2}. The mass of this body must be

(a) $2\sqrt{10}$ kg (b) 10 kg
(c) 20 kg (d) $10\sqrt{2}$ kg

NDA (II)-2014
AIPMT- 2009

Ans. (d) : Given,
Force $F = 6\hat{i} - 8\hat{j} + 10\hat{k}$

$$a = 1 \text{ m/s}^2$$
$$|\vec{F}| = \sqrt{6^2 + (-8)^2 + 10^2}$$
$$|\vec{F}| = \sqrt{36 + 64 + 100}$$
$$|\vec{F}| = \sqrt{200}$$
$$|\vec{F}| = 10\sqrt{2}$$
$$\therefore \quad F = ma$$
$$10\sqrt{2} = m \times 1$$
$$m = 10\sqrt{2} \text{ kg}$$

50. A ball of mass 100 g is moving with a velocity of 10 ms^{-1}. On being hit with bat rebounds with a velocity of 10 ms^{-1}. The force of the ball by the bat acts for 0.01 s, then the force exerted on the ball by the bat is

(a) 50 N (b) 100 N
(c) 200 N (d) 400 N

EAMCET-1992

Ans. (c): Initial velocity of ball u = –10m/s
Initial momentum $p_i = mu = 0.1$ □ $(-10) = -1$kg m/s
final momentum $p_f = mv = 0.1$ □ $10 = 1$kg m/s
Time of action t = 0.01s
Using F □ t = $p_f - p_i$
F □ 0.01 = 1 – (–1) = 2
F = 200N

51. Two forces of equal magnitude F act at a point. If the angle between them is θ, then the magnitude of the resultant force is

(a) $F\sqrt{2(1-\sin\theta)}$ (b) $F\sqrt{2(1+\sin\theta)}$
(c) $2F\sin\frac{\theta}{2}$ (d) $2F\cos\left(\frac{\theta}{2}\right)$

EAMCET-1995

Ans. (d): Magnitude of resultant of two force.

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$
$$\therefore \quad F_1 = F_2 = F$$
$$\therefore \quad R = \sqrt{F^2 + F^2 + 2F.F\cos\theta}$$
$$R = \sqrt{2F^2 + 2F^2\cos\theta}$$
$$R = \sqrt{2F^2(1+\cos\theta)} \quad \left\{\because 1 + \cos\theta = 2\cos^2\frac{\theta}{2}\right\}$$
$$R = \sqrt{2F^2\left(2\cos^2\frac{\theta}{2}\right)}$$
$$R = \sqrt{4F^2\cos^2\frac{\theta}{2}}$$
$$R = 2F\cos\frac{\theta}{2}$$

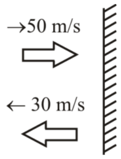
@apna_pdf

52. **Bullets of 0.03 kg mass each, hit a plate at the rate of 200 bullet/s, with a velocity of 50 ms^{-1} and reflect back with a velocity of 30 ms^{-1}. The average force acting on the plate, in Newton is**

(a) 120 (b) 180
(c) 300 (d) 480

EAMCET-1998

Ans. (d):



Momentum of each bullet = mv
Momentum of total bullet in one second = n mv
Here,
n = 200, m = 0.03 $v_1 = -50$ m/s, $v_2 = 30$ m/s, t = 1sec

$$\text{Force exerted on the plate} = \frac{dp}{dt}$$
$$= \frac{nm[v_2 - v_1]}{t}$$

So,
$$F = 200 \times 0.03\ [30 - (-50)]$$
$$= 200 \times 0.03 \times 80$$
$$= 480\text{ N}$$

53. **If a light body and a heavy body have equal momentum, then**

(a) The lighter body has greater kinetic energy than the heavier body
(b) The lighter body has less kinetic energy than the heavier body
(c) The kinetic energy of the lighter body is equal to the kinetic energy of the heavier body
(d) The kinetic energy of both the bodies are independent of momentum

NDA (II) 2009

Ans. : (a) As we know,
The relation between kinetic energy (k) and momentum (p) is,
$$k = \frac{p^2}{2m}$$
As p is constant then
$$k \propto \frac{1}{m}$$
Thus Lighter body has more kinetic energy.

54. **A force F is applied on a body (which moves on a straight line) for a duration of 3s. The momentum of the body changes from 10 g cm/s to 40 g cm/s. The magnitude of the force F is**

(a) 10 dynes (b) 10 Newton
(c) 120 dynes (d) 12 dynes

NDA (I) 2013

Ans. (a) : Given,
$p_1 = 10$ g cm/s
$p_2 = 40$ g cm/s
Time, t = 3s

Applying second law of motion
$$\text{Force, } F = \frac{p_2 - p_1}{t}$$
$$\Rightarrow F = \frac{40-10}{3} = \frac{30}{3} = 10\text{ dyne}$$

55. **When a force of 1 Newton acts on a mass of 1kg which is able to move freely, the object moves in the direction of force with a/an**

(a) speed of 1 km/s (b) acceleration of 1m/s^2
(c) speed of 1m/s (d) acceleration of 1km/s^2

NDA (II) 2016

Ans. (b) : Given,
Force, F = 1 Newton
Mass, m = 1 kg
Applying second law of motion,
F = ma
$1 = 1 \times a$
$a = 1\ m/s^2$

56. **A body of mass m= 3.513 kg is moving along the x-axis with a speed of 5.00 ms^{-1}. The magnitude of its momentum is recorded as**

(a) 17.6 kg ms^{-1} (b) 17.565 kg ms^{-1}
(c) 17.56 kg ms^{-1} (d) 17.57 kg ms^{-1}

AIEEE 2008

Ans. (b) : Given,
Mass, m = 3.513 kg
Velocity, v = 5 m/s
The magnitude of its momentum is
p = mv
$p = 3.513 \times 5$
p = 17.565 kg m/s

57. **A diwali rocket is ejecting 0.05 kg of gases per second at a velocity of 400 m/s. The accelerating force on the rocket is**

(a) 20 N (b) 2 N
(c) 100 N (d) 200 N

AMU-2004

Ans. (a) : Force = Rate of change in momentum.
$$F = \frac{dP}{dt} = \frac{d(mv)}{dt} = \frac{dm}{dt}\cdot v$$
$$= 0.05 \times 400 = 20\text{ N}$$

58. **The linear momentum of a particle varies with time t as $P = a + bt + ct^2$. Then which of the following is correct?**

(a) Force is dependent linearly on time
(b) Velocity of particle is inversely proportional to time
(c) Displacement of the particle is independent of time
(d) Force varies with time in a quadratic manner.

AP EAMCET(Medical)-2014

Ans. (a) : Given,
$P = a + bt + ct^2$
The force acting on particle = Rate of change of momentum
$$F = \frac{dP}{dt}$$

@apna_pdf

$$\therefore \quad F = \frac{d}{dt}\left(a + bt + ct^2\right)$$

$$\square \quad F = b + 2ct \qquad \text{(linear equation)}$$

So, the force acting on the particle is linearly dependent on time.

59. Three forces A = (i + j + k), B = (2i – j +3k) and C acting on a body to keep it in equilibrium. Then C is

(a) –(3i + 4k) (b) –(4i + 3k)
(c) 3i + 4j (d) 2i – 3k

AP EMCET(Medical)-2008

Ans. (a) : Given,
Three forces,

$$A = (i + j + k)$$
$$B = (2i - j + 3k),\ C$$
$$\because \quad \vec{A} + \vec{B} + \vec{C} = 0$$
$$\left(\hat{i} + \hat{j} + \hat{k}\right) + \left(2\hat{i} - \hat{j} + 3\hat{k}\right) + \vec{C} = 0$$
$$3\hat{i} + 4\hat{k} + \vec{C} = 0$$
$$\vec{C} = -3\hat{i} - 4\hat{j}$$
$$\vec{C} = -\left(3\hat{i} + 4\hat{j}\right)$$

60. A mass m falls freely from rest. The linear momentum, after it has fallen through a height h, is :
(g = acceleration due to gravity)

(a) $\sqrt{mgh}$ (b) $m\sqrt{2gh}$
(c) $m\sqrt{gh}$ (d) zero

AP EAMCET(Medical)-1998

Ans. (b) : We know that,
Newton's third's law of motion,

$$v^2 = u^2 + 2gh$$

When initial velocity, u = 0
Then,

$$v^2 = 2gh$$
$$v = \sqrt{2gh}$$

The linear momentum, P = mv

$$P = m \times \sqrt{2gh} \qquad \left\{\because v = \sqrt{2gh}\right\}$$
$$P = m\sqrt{2gh}$$

61. Two masses of m and 4m are moving with equal kinetic energy. The ratio of their linear momentum is

(a) 1 : 8 (b) 1 : 4
(c) 1 : 2 (d) 4 : 1

DCE-2009

Ans. (c) : Given, $m_1 = m$

$$m_2 = 4m$$
$$(KE)_1 = (KE)_2$$

We know that,

$$\because \quad P_1 = \sqrt{2m_1(KE)_1}$$
$$P = \sqrt{2m(KE)_1} \qquad \text{......... (i)}$$
$$P_2 = \sqrt{2m_2(KE)_2}$$
$$P_2 = \sqrt{2 \times 4m(KE)_2} \qquad \text{......... (ii)}$$

from eqn (i) and (ii)

$$\Rightarrow \quad \frac{P_1}{P_2} = \sqrt{\frac{m}{4m}} = \frac{1}{2} \qquad \left[\because (KE)_1 = (KE)_2\right]$$

62. The one which does not represent a force in any context is

(a) friction (b) impulse
(c) tension (d) weight
(e) viscous drag

Kerala CEE - 2016

Ans. (b) : Impulse is defined as overall effect of a force acting over time and it expressed in Newton-seconds.
Impulse = changes in Momentum
∴ Impulse is does not represent force.

63. A ball of mass 10g moving perpendicular to the plane of the wall strikes it and rebounds in the same line with the same velocity. If the impulse experienced by the wall is 0.54 Ns, the velocity of the ball is

(a) 27 ms^{-1} (b) 3.7 ms^{-1}
(c) 54 ms^{-1} (d) 37 ms^{-1}
(e) 5.4 ms^{-1}

Kerala CEE- 2014

Ans. (a) : Given that,

$$m = 10g = 10 \times 10^{-3}\ \text{kg}$$
$$I = 0.54\ \text{NS}$$
$$V = ?$$

Impulse = change in momentum

$$\square = mv - (-mv)$$
$$0.54 = 2mv$$
$$v = \frac{0.54}{2 \times 10 \times 10^{-3}}$$
$$v = 27\ \text{m/s}$$

64. For a system to follow the law of conservation of linear momentum during a collision, the condition is

(i) Total external force acting on the system is zero.
(ii) Total external force acting on the system is finite and time of collision in negligible.
(iii) Total internal force acting on the system is zero

(a) (i) only (b) (ii) only
(c) (iii) only (d) (i) or (ii)

JCECE-2009

Ans. (a) : From Newton 2nd law of motion,

$$F = \frac{dp}{dt} = \text{Rate of change of momentum}$$

When F = 0 then $\frac{dp}{dt} = 0$

∴ p = constant

So, linear momentum is conserved.

65. For ordinary terrestrial experiments, the observer in an inertial frame in the following cases is

(a) a child revolving in a giant wheel

@apna_pdf

(b) a driver in a sports car moving with a constant high speed of 200 kmh^{-1} on a straight rod
(c) the pilot of an aeroplane which is taking off
(d) a cyclist negotiating a sharp curve

JCECE-2009

Ans. (b) : Acceleration is zero and inertial frame is an non-accelerated frame. Therefore a driver in a sports car moving with a constant high speed of 200 km/h on a straight rod is non-accelerating.

66. A particle of mass m is moving with a uniform velocity v_1. It is given an impulse such that its velocity becomes v_2. The impulse is equal to

(a) $m\left[|v_2|-|v_1|\right]$ (b) $\frac{1}{2}m\left(v_2^2-v_1^2\right)$
(c) $m(v_1+v_2)$ (d) $m(v_2-v_1)$

AIPMT- 1990

Ans. (d) : Impulse is a vector quantity and is equal to change in momentum of the body.

$\because$ Impulse = $\Delta P = P_f - P_i$

Impulse = $m(v_2 - v_1)$

67. A ball of mass 150 g moving with an acceleration 20 m/s^2 is hit by a force, which acts on it for 0.1 s. The impulsive force is

(a) 0.5 N-s (b) 0.1 N-s
(c) 0.3 N-s (d) 1.2 N-s

AIPMT- 1996

Ans. (c) : Given that,

mass of ball = 150 g, $a = 20\ m/s^2$

t = 0.1s

We know

$f = ma = 150 \times 10^{-3} \times 20 = 3N$

Impulse = f × t

$\therefore$ Impulse = 3 × 0.1= 0.3 N–s

68. A player takes 0.1 s in catching ball of mass 150 g moving with velocity of 20 m/s. The force imparted by the ball in the hands of the player is

(a) 0.3 N (b) 3 N
(c) 30 N (d) 300 N

AIPMT- 2001

Ans. (c) : Given that,

Mass = 150g

u = 20m/s

$\Delta t = 0.1s$

F = Rate of change of momentum

$$F = \frac{m(v-u)}{t}$$

$$F = \frac{0.15(0-20)}{0.1}$$

F = –30N

The magnitude of the force is 30N and the direction will be opposite to the direction of the previous motion of the ball.

Hence, the force exerted by the ball on the hand of the player is 30 N.

69. 1 kg body explodes into three fragments. The ratio of their masses is 1: 1: 3. The fragments of same mass move perpendicular to each other with speeds 30 m/s, while the heavier part remains in the initial direction. The speed of heavier part is

(a) $\frac{10}{\sqrt{2}}$ m/s (b) $10\sqrt{2}$ m/s
(c) $20\sqrt{2}$ m/s (d) $30\sqrt{2}$ m/s

AIPMT- 2001

Ans. (b) : Let mass of three fragments be m_1, m_2 and m_3

$$\therefore m_1 = \frac{1}{5} = 0.2kg$$

$$m_2 = \frac{1}{5} = 0.2kg$$

$$m_3 = \frac{3}{5} = 0.6kg$$

We know,

Momentum (p) = mv

$\therefore$ $p_1 = m_1v = 0.2 \times 30 = 6$ kgm/s

$p_2 = m_2v = 0.2 \times 30 = 6$ kgm/s

$\therefore$ p_3 will in opposite direction of resultant of A and p_2

So, that the momentum of the system become zero,

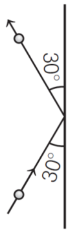
$$\therefore p_3 = \sqrt{p_1^2+p_2^2}$$

$$p_3 = \sqrt{6^2+6^2} = 6\sqrt{2}\,kg\,m/s$$

Thus speed of third fragments

$$v_3 = \frac{p_3}{m_3} = \frac{6\sqrt{2}}{0.6} = 10\sqrt{2}\,m/s$$

70. A 0.5 kg ball moving with a speed of 12 m/s strikes a hard wall at an angle of 30° with the wall. It is reflected with the same speed and at the same angle. If the ball is in contact with the wall for 0.25 s, the average force acting on the wall is



(a) 48 N (b) 24 N
(c) 12 N (d) 96 N

AIPMT- 2006

Ans. (b) Given that,

m = 3kg

v = 12 m/s

θ = 30º

t = 0.25sec.

$\therefore$ Angle is given from vertical component

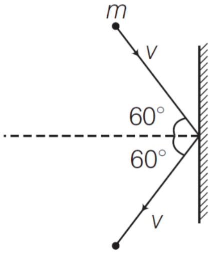
Hence,

$$F = \frac{2mv\sin\theta}{t} = \frac{2\times3\times12\times\sin30^\circ}{0.25}$$

F = 24 N

71. A rigid ball of mass m strikes a rigid wall at 60° and gets reflected without loss of speed as shown in the figure. The value of impulse imparted by the wall on the ball will be

@apna_pdf



(a) mv (b) 2mv
(c) mv/2 (d) mv/3

AIPMT- 2000
NEET- 2016

Ans. (a) : Given, mass of ball = m, angle (θ) = 60°
We know that,
Impulse $(I) = F.\Delta t$

$$I = \frac{\Delta p}{\Delta t}.\Delta t$$

$$I = \Delta p$$

Hence,
Change in momentum (Δp) = 2mv cosθ
∴ $I = 2mv\cos 60^\circ$

$$I = 2mv\frac{1}{2}$$

$$I = m.v$$

Hence, impulse imparted by the wall on the ball is m.v.

72. N bullets each of mass m kg are fired with a velocity v ms^{-1} at the rate of n bullets per second upon a wall. The reaction offered by the wall to the bullets is given by

(a) nmv (b) $\frac{Nmv}{n}$
(c) $\frac{nNm}{v}$ (d) $\frac{nNv}{m}$

UP CPMT-2011

Ans. (a) : If mass of each bullet = m kg
Then, total mass of bullets = Nm kg

$$\text{Time } t = \frac{N}{n} = \frac{\text{No. of bullet}}{\text{No. of bullet / sec}}$$

Momentum of the bullets striking the wall = N mv

$$\text{Rate of change of momentum } = \frac{N\,mv}{t} = \frac{Nmvn}{N}$$
$$= nmv$$

73. The distance covered by a body of mass 5 g having linear momentum 0.3 kg m/s in 5s is:

(a) 300 m (b) 30 m
(c) 3 m (d) 0.3 m

SRM JEE-2014

Ans. (a) : Given data,
m = 5g
Linear momentum, p = 0.3 kg-m/sec
t = 5 sec
Distance (d) = ?
We know that,
p = mv

$$v = \frac{p}{m} \Rightarrow \frac{0.3\times1000}{5}$$

v = 60 m/sec

$$\because \text{ velocity, } v = \frac{d}{t}$$

So, d = vt
d = 60 × 5
d = 300 m

74. A bullet of mass 20 g moving with a speed of 100 m s^{-1} enters a heavy wooden block and stops after a distance of 50 cm. The average resistive force exerted by the block on the bullet is

(a) 100 N (b) 10000 N
(c) 200 N (d) 500 N

Assam CEE-2016

Ans. (c) : Given that,
$u = 100\text{ ms}^{-1}$, v = 0

$$m = 20g = \frac{20}{1000}kg = 0.02kg$$

s = 50cm = 0.5 m
Use the third equation of motion,
$v^2 - u^2 = 2as$
∴ $(0)^2 - (100)^2 = 2a\times0.5$

$$a = \frac{(100)^2}{2\times0.5} = -10000\text{ ms}^{-2}$$

Negative sign shows the retardation.
∴ The average resistive force exerted by block on the bullet is
F = m × a
= 0.02×10,000
= 200 N

75. A gun of mass 10kg fires 4 bullets per second. The mass of each bullet is 20g and the velocity of the bullet when it leaves the gun is 300ms^{-1} . The force required to hold the gun while firing is:

(a) 6N (b) 8N
(c) 24N (d) 240N

AP EAMCET(Medical)-2000

Ans. (c) : Given data,
Mass of each bullet (m) = 20g = 20×10^{-3}kg
No. of bullet (n) = 4
Velocity (v) = 300 ms^{-1}
Time (t) = 1 sec
Force = ?
According to Newton's second law, the rate of change in momentum (p) of an object is equal to the force (F) applied.

$$F = \frac{dp}{dt}$$

$$F = \frac{d(mv)}{dt} \qquad [\because p = mv]$$

$$F_{single} = m\frac{dv}{dt}$$

$$\frac{dv}{dt}\times m = ma \qquad \left[\because a = \frac{dv}{dt}\right]$$

$$F_{single} = \frac{300}{1}\times20\times10^{-3} \Rightarrow 6N$$

So, $F_{Total} = n\times F_{single}$
$F_{Total} = 4 \times 6 = 24$ N

@apna_pdf

76. **A force of 100 N acts on a body of mass 2 kg for 10 s. The change in momentum of the body is:**

(a) 100 Ns (b) 250 Ns
(c) 500 Ns (d) 1000 Ns

AP EAMCET(Medical)-1999

Ans. (d) : Given data,
Mass of body (m) = 2kg
Applied force (F) = 100 N
Time (t) = 10 sec
By Newton's second law,
The rate of change of momentum is directly proportional to the force.

$$\frac{\Delta p}{\Delta t} \propto F$$

$$\frac{\Delta p}{\Delta t} = F$$

$\Delta p = F.\Delta t$
$\Delta p = 100\text{ N} \times 10\text{ s} = 1000\text{ Ns}$

77. **If n bullets each of mass m are fired with a velocity v per second from a machine gun, the force required to hold the gun in position is**

(a) $(n + 1)$ mv (b) $\frac{mv}{n^2}$
(c) $\frac{mv}{n}$ (d) n^2mv
(e) mnv

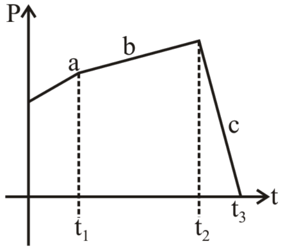
Kerala CEE - 2015

Ans. (e) : Given,
Number of bullet = n
Mass of bullet = m
Velocity of bullet = v
The force required to hold the gun in position is

$$\text{Net force} = \Delta p/\Delta t = \frac{mnv}{1}$$
$$= mnv$$

(b) Newton's Law of Motion and It's Application

78. **The figure represents the momentum time (p-t) curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively? If $(t_3 - t_2)t_1$**



(a) c and b (b) a and b
(c) b and c (d) c and a

JEE Main-30.01.2023, Shift-I

Ans. (a) : From Newton's 2nd law of motion,

$$\vec{F} = \frac{d\vec{p}}{dt}$$

For, F_{max} = Slope is maximum.
F_{min} = Slope is minimum.

79. **100 balls each of mass m moving with speed v simultaneously strike a wall normally and reflected back with same speed, in time t s. The total force exerted by the balls on the wall is**

(a) $\frac{100mv}{t}$ (b) 200mvt
(c) $\frac{200mv}{t}$ (d) $\frac{mv}{100t}$

JEE Main-31.01.2023, Shift-I

Ans. (c) : Given, mass = m, speed = v, time = t
Number of balls = 100
We know that,

$$F = \frac{\Delta p}{\Delta t}$$

$$F = \frac{mv-(-mv)}{t} = \frac{2mv}{t}$$

For 100 balls, total force exerted by the balls on the wall is –

$$F_{net} = 100 \times \frac{2mv}{t} = \frac{200mv}{t}$$

80. **Passengers standing in a bus are thrown outwards when the bus takes a sudden turn. This happens because of**

(a) Outward pull on them
(b) Inertia
(c) Change in momentum
(d) Change in acceleration

AP EAMCET-07.10.2020, Shift-I
AP EAMCET-07.09.2021, Shift-I

Ans. (b) : Newton's first law of inertia states that an object will change its direction when a force is applied to it. Hence, when a bus takes a sudden turn the passengers are thrown outward. This is due to the inertia of direction.

81. **When a metal wire of length 'l' is subjected to tensions T_1 and T_2 respectively its length changes to l_1 and l_2, then the relation of 'l' is correctly given by**

(a) $l\sqrt{l_1 - l_2}$ (b) $l = \frac{1}{2}(l_1 + l_2)$
(c) $l = \frac{l_1T_2 + l_2T_1}{T_1 + T_2}$ (d) $l = \frac{l_1T_2 - l_2T_1}{T_1 - T_2}$

Tripura-2021
Assam CEE-2014

Ans. (d) : Given,
Tension is T_1 when length is l_1 and when, length is l_2, tension is T_2.
Let natural length of wire is l

@apna_pdf

$\because$ Young's modules (E) = $\dfrac{\text{Stress}}{\text{Strain}}$

$$E = \frac{T\times l}{A\times \Delta l}$$

(i) When length is l_1 and tension is T_1

$$E = \frac{T_1\times l}{A(l_1 - l)}$$

(ii) When length is l_2 and tension is T_2

$$E = \frac{T_2\times l}{A(l_2 - l)}$$

$\because$ E is equal in both case,

$$\frac{T_1\times l}{A(l_1 - l)} = \frac{T_2\times l}{A(l_2 - l)}$$

$$T_1l_2 - T_1l = T_2l_1 - T_2l$$

$$l(T_2 - T_1) = T_2l_1 - T_1l_2$$

$$l = \frac{T_2l_1 - T_1l_2}{T_2 - T_1}$$

82. The ratio of weights of a man inside a lift when it is stationary and when it is going down with a uniform acceleration 'a' is 3:2. The value of 'a' will be (a<g, g= acceleration due to gravity)

(a) $\frac{3}{2}g$ (b) $\frac{g}{3}$

(c) g (d) $\frac{2}{3}g$

MHT-CET 2020
NDA (II) 2011

Ans. (b) : When the lift is stationary the weight of the man is $w_o = mg$

The weight of the man when the lift is moving downward with acceleration a is $w = mg - ma$

$$\frac{w_o}{w} = \frac{3}{2}\text{(given)}$$

Therefore, $\dfrac{mg}{mg - ma} = \dfrac{3}{2}$

$$\frac{mg}{m(g-a)} = \frac{3}{2}$$

$$2g = 3g - 3a$$

$$g = 3a$$

So, $a = \dfrac{g}{3}$

83. A block of mass m is resting on a smooth horizontal surface. One end of a uniform rope of mass $\left(\frac{m}{3}\right)$ is fixed to the block, which is pulled in the horizontal direction by applying force F at the other end. The tension in the middle of the rope is

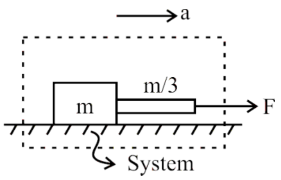
(a) $\frac{8}{7}F$ (b) $\frac{1}{7}F$

(c) $\frac{1}{8}F$ (d) $\frac{1}{5}F$

(e) $\frac{7}{8}F$

BECEC - 2018
Kerala CEE - 2009

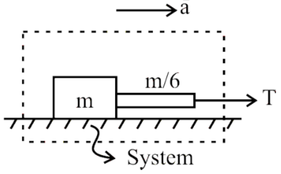
Ans. (e) :



$$F = m_1a$$

$$a = \left(\frac{F}{m + \frac{m}{3}}\right) = \frac{3F}{4m}$$

$\therefore$ Now, Tension at middle of rope



$$\therefore\ T = \left(m + \frac{m}{6}\right)\left(\frac{F}{m + \frac{m}{3}}\right) = \frac{7m}{6}\times\frac{3F}{4m}$$

$$T = \frac{7F}{8}$$

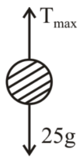
84. A monkey of mass 20 kg is holding a vertical rope. The rope will not break, when a mass of 25 kg is suspended from it but will break, if the mass exceeds 25 kg. What is the maximum acceleration with which the monkey can climb up along the rope? (Take g = 10m/s^2)

(a) 25 m/s^2 (b) 2.5 m/s^2

(c) 5 m/s^2 (d) 10 m/s^2

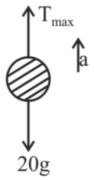
AIPMT- 2003
JCECE-2012

Ans. (b) : Case I:- Maximum mass 25 kg is applied.



$\therefore$ $T_{max} = 25\times10 = 250N$ (breaking force)

Case I: mass of monkey of 20 kg moving upward with acceleration a



@apna_pdf

We know,

$$T_{max} = mg + ma$$
$$250 = 20g + 20a$$
$$250 = 200 + 20a$$
$$20a = 250 - 200$$
$$a = \frac{50}{20}$$
$$a = 2.5 \text{ m/s}^2$$

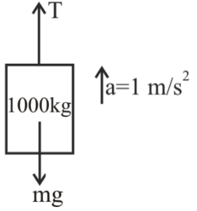
85. A lift of mass 1000 kg is moving upwards with an acceleration of 1 m/s². The tension developed in the string, which is connected to lift is ($g = 9.8 \text{m/s}^2$)

(a) 9800 N (b) 10800 N
(c) 11000 N (d) 10000 N

AIPMT- 2002
N.D.A. (II) - 2003, 2009

Ans. (b) : Given that,

$m = 1000$ kg, $a = 1 \text{ m/s}^2$



String connected to the lift (upward) $T = mg + ma$

$$T = m(g + a)$$
$$T = 1000\,(9.8 + 1)$$
$$T = 10800 \text{ N}$$

86. A stationary body of mass 3 kg explodes into three equal pieces. Two of the pieces fly off in two mutually perpendicular directions, one with a velocity of $3\hat{i}\text{ms}^{-1}$ and the other with a velocity of $4\hat{j}\text{ms}^{-1}$. If the explosion occurs in 10^{-4}s, the average force acting on the third piece in Newton is

(a) $(3\hat{i}+4\hat{j})\times10^{-4}$ (b) $(3\hat{i}-4\hat{j})\times10^{-4}$
(c) $(3\hat{i}+4\hat{j})\times10^{4}$ (d) $-(3\hat{i}+4\hat{j})\times10^{4}$
(e) $(4\hat{i}-3\hat{j})\times10^{4}$

Kerala CEE - 2009
JCECE-2010

Ans. (d) : Given, $m_1 = m_2 = m_3 = 1$ kg, $t = 10^{-4}$ s

$$\vec{v}_1 = 3\hat{i}, \vec{v}_2 = 4\hat{j}$$

By law of conservation of linear momentum–

$$m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3 = 0$$
$$\therefore \quad 3\hat{i} + 4\hat{j} + \vec{v}_3 = 0$$
$$\vec{v}_3 = -\left(3\hat{i} + 4\hat{j}\right)$$

The average force acting on the third piece is–

$$F = \frac{m\vec{v}_3}{t}$$
$$= \frac{1\times-(3\hat{i}+4\hat{j})}{10^{-4}}\text{N}$$
$$= -(3\hat{i}+4\hat{j})\times10^{4}\text{N}$$

87. A golf ball of mass 50 gm placed on a tee, is truck by a golf-club. The speed of the golf ball as it leaves the tee is 100 m/s, the time of contact on the ball is 0.02 s. If the force decreases to zero linearly with time, then the force at the beginning of the contact is

(a) 100 N (b) 200 N
(c) 250 N (d) 500 N

WB JEE 2022

Ans. (c) : Given,
m = 50 gm = 0.05 kg
v = 100 m/s
t = 0.02 sec

$$a = \frac{v}{t} = \frac{100}{0.02} = \frac{100\times100}{2}$$
$$a = 5000 \text{ m/s}^2$$

Now,

$$F = m \times a$$
$$= 0.05 \times 5 \times 10^3 = 250 \text{ N}$$

Hence, the force at the beginning of the contact is 250 N.

88. Assertion [A]: A boy feels more pain when he falls down on a hard concrete floor than when he falls on the sand floor
Reason [R]: Every action has equal and opposite reaction. The time of impact of cement floor is smaller compared to that of sand floor

(a) [A] and [R] are true and [R] is correct explanation of [A]
(b) [A] and [R] are true and [R] is not correct explanation of [A]
(c) [A] is true and [R] is false
(d) [A] is false, and [R] is true

AP EAMCET-11.07.2022, Shift-I

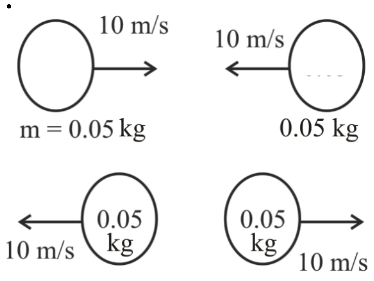
Ans. (a) When a boy falls on a concrete floor, his body comes to rest instantly. Change is momentum is constant. As time of stopping decreases, force increases hence, boy feels inure pain.
When he falls on sand floor, the time of stopping increases, hence force decreases and we fells has pain.

89. Two billiard balls of mass 0.05 kg each moving in opposite directions with 10ms⁻¹ collide and rebound with the same speed. If the time duration of contact is t = 0.005 s, then what is then force exerted on the ball due to each other?

(a) 100 N (b) 200 N
(c) 300 N (d) 400 N

JEE Main-25.07.2022, Shift-II

Ans. (b) :



Given,
Mass of each ball = 0.05 kg
Initial velocity (v_i) = 10 m/s

@apna_pdf

Final velocity (v_f) = 10 m/s

We know that,

Momentum = mv

Initial momentum (p_i) = 0.05 × 10

p_i = 0.5 kg m/s

After collision, the balls change their direction of motion

∴ Final momentum (p_f) = 0.05 × (–10)

= –0.5 kg m/s

∴ Impulse of one ball = 0.5–(–0.5)

(Δp) = 1

$$\therefore \text{ Exerted force} = \frac{\Delta P}{\Delta t} = \frac{1}{0.005} = 200 \text{ N}$$

90. A monkey of mass 50kg climbs on a rope which can withstand the tension (T) of 350N. If monkey initially climbs down with an acceleration of 4m/s^2 and then climbs up with an acceleration of 5m/s^2. Choose the correct option (g = 10m/s^2)

(a) T = 700N while climbing upward
(b) T = 350 N while going downward
(c) Rope will break while climbing upward
(d) Rope will break while going downward

JEE Main-26.07.2022, Shift-I

Ans. (c) : Given,

Mass of monkey = 50kg

Breaking strength = 350 N

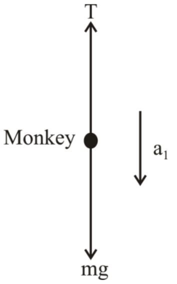
Upward acceleration = 5 m/s^2

(i) Monkey moving downward,

$mg - T = ma_1$

$50 \times 10 - T = 50 \times 4$

T = 300 N

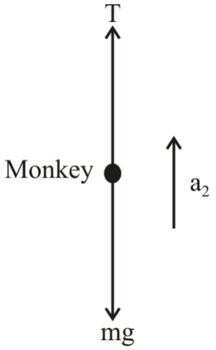


(ii) Monkey moving upward.

$T - mg = ma_2$

$T - 50 \times 10 = 50 \times 5$

T = 750



Braking strength is 350N. So, String will break while monkey is moving upward.

91. A person is standing in an elevator. In which situation, he experiences weight loss?

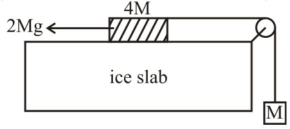
(a) When the elevator moves upward with constant acceleration
(b) When the elevator moves downward with constant acceleration
(c) When the elevator moves upward with uniform velocity
(d) When the elevator moves downward with uniform velocity

JEE Main-26.06.2022, Shift-I

Ans. (b) : When a person is standing in an elevator, he will feel his weight less. When the lift goes down with acceleration because of the pseudo force acting on it is in the upward direction thus reducing the effective gravitational force in the frame of the lift.

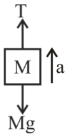
Hence, when the elevator moves downward with constant acceleration, person feel weight loss.

92. A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement, as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by 2 Mg force. In this situation, tension in the string is $\frac{x}{5}$ Mg for x = ________. Neglect mass of the string and friction of the block (bigger mass) with ice slab. (Given g = acceleration due to gravity)



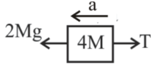
JEE Main-28.06.2022, Shift-I

Ans. (6) :



$T - Ma = Mg$

$T = Mg + Ma$ …..(i)



$2Mg - T = 4Ma$

$T = 2Mg - 4Ma$ …..(ii)

From equation (i) and (ii)

$Mg + Ma = 2Mg - 4Ma$

$5\,Ma = Mg$

$$a = \frac{g}{5}$$

$$\because T = Mg + M\left(\frac{g}{5}\right)$$

$$= Mg + \frac{Mg}{5}$$

$$T = \frac{6Mg}{5}$$

$$\boxed{x = 6}$$

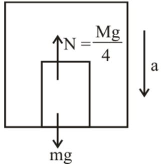
@apna_pdf

93. A block of mass M placed inside a box descends vertically with acceleration 'a'. The block exerts a force equal to one fourth of its weight on the floor of the box. The value of 'a' will be

(a) $\frac{g}{4}$ (b) $\frac{g}{2}$ (c) $\frac{3g}{4}$ (d) g

JEE Main-29.06.2022, Shift-II

Ans. (c) : Block of mass M is descending downward with acceleration 'a',



Then, $mg - N = ma$

$$mg - \frac{mg}{4} = ma$$

$$a = g - \frac{g}{4}$$

$$a = \frac{3g}{4}$$

94. Identical guns fire identical bullets horizontally at the same speed from the same height above level planes, one on the Earth and another one on the Moon. Which of the following statement are "TRUE"?

I) The horizontal distance travelled by the bullet is greater for the moon.

II) The flight time is less for the bullet on the Earth.

III) The velocities of the bullets at impact are the same.

(a) III only (b) I and III only

(c) I and II only (d) II and III only

TS EAMCET 31.07.2022, Shift-II

Ans. (c) : The horizontal distance covered by the bullet at a certain height from the ground is increased proportional to the acceleration due to gravity acting on the body.

i.e. $x \propto \frac{1}{g}$

As the value of g on the moon is less than that on earth therefore the horizontal distance covered by the bullet on the moon will be greater.

• The time of flight of a projectile is given by

$$t = \frac{2v\sin\theta}{g}$$

$$\Rightarrow t \propto \frac{1}{g}$$

Thus the time of flight on the earth will be less.

• The velocity of bullet is dependent on the acceleration due of gravity acting on the body. The velocity of the bullet can be given as,

$v = v_0 \sin\theta - gt$

So, the velocity of the bullet will be different for both the places (earth and moon)

95. A bullet of mass 10 g is horizontally fired with velocity 300 m s^{-1} from a pistol of mass 1 kg. What is the recoil velocity of the pistol?

(a) 0.3 m s^{-1} (b) 3 m s^{-1}

(c) – 3 m s^{-1} (d) – 0.3 m s^{-1}

UPSC NDA-04.09.2022

Ans. (b) : Given,

$m_1 = 10g = 0.01$ kg

$v_1 = 300$ m/s

Mass of pistol $(m_2) = 1$kg

$v_2 = ?$

We know that,

$m_1 \times v_1 = m_2 \times v_2$

$0.01 \times 300 = 1 \times v_2$

$3 = v_2$

or

$v_2 = 3$ m s^{-1}

96. Which one of the following statement is INCORRECT?

(a) The state of rest or uniform linear motion both imply zero acceleration.

(b) A net force is needed to keep a body in uniform motion.

(c) Inertia means resistance to change.

(d) The rate of change of momentum is proportional to the applied force.

(e) Momentum is a vector quantity.

Kerala CEE 2021

Ans. (b) : In uniform motion, velocity is constant

$\therefore \quad a = 0$

$\therefore \quad F_{net} = 0$

97. On a conveyor belt moving with a speed u, sand falls at a constant rate $\left(\frac{dm}{dt}\right)$, where m is the mass of sand. The extra force required to maintain the speed of the belt is

(a) $m\left(\frac{du}{dt}\right)$ (b) mu

(c) $\left(\frac{dm}{dt}\right)/u$ (d) $u\left(\frac{dm}{dt}\right)$

(e) $\frac{1}{m}\left(\frac{dm}{dt}\right)$

Kerala CEE 2021

Ans. (d) : Given:- Uniform speed of conveyor belt = u

Mass of sand = m

We know that,

$$F_{ext} = \frac{dp}{dt}$$

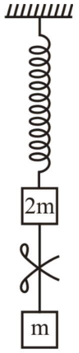
But p = mu

$$\therefore F_{ext} = \frac{d(mu)}{dt} = u\left(\frac{dm}{dt}\right) \text{.....}(\because \text{u is constant })$$

$$\therefore F_{ext} = u\left(\frac{dm}{dt}\right)$$

98. A system as shown in figure is in equilibrium and is at rest. The spring and string are massless, now the string is cut. The acceleration of the masses '2m' and 'm' just after the string is cut, will be

@apna_pdf



(a) $\frac{g}{2}$ upwards, g downwards

(b) g upwards, $\frac{g}{2}$ downwards

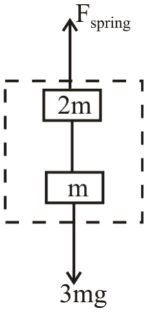
(c) g upwards, 2g downwards

(d) 2g upwards, g downwards

TS EAMCET 05.08.2021, Shift-I

Ans. (a) : FBD of system:

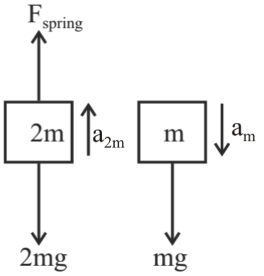
When the system is in equilibrium



$$\sum F_y = 0$$

Then, $F_{spring} = 3mg$

When the string is cut tension in the string becomes zero, T = 0



Acceleration of block of mass m

$$(a)_m = \frac{mg}{m} = g(\downarrow)$$

Acceleration of block of mass 2m

$$(a)_m = \frac{F_{spring} - 2mg}{2m} = \frac{3mg - 2mg}{2m}$$

$$\therefore (a)_{2m} = \frac{g}{2}(\uparrow)$$

Hence, the acceleration of the mass (2m) is upward with acceleration g/2 while acceleration of the mass 'm' is in downward direction with acceleration g.

99. A ball of mass 0.2 kg moving with a speed of 20 m/s is brought to rest in 0.1 s. The average force applied to the ball is

(a) 20 N (b) 30 N

(c) 40 N (d) 60 N

TS EAMCET 05.08.2021, Shift-I

Ans. (c) : Given that,

Ball of mass, (m) = 0.2 kg

Ball moving with speed, u = 20m/s

Ball rest in, t = 0.1 sec and v = 0

We know that,

$$v = u + at$$

$$0 = 20 + a \times 0.1$$

$$a = \frac{-20}{0.1} = -200\,m/s^2$$

Then, to find average force applied to the ball is,

$$F = ma$$

$$F = 0.2 \times -200$$

$$\therefore |F| = 40\text{ N}$$

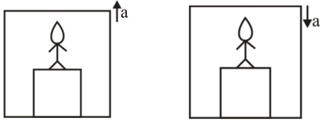
100. Imagine a person standing on a weighing machine placed inside an elevator. The elevator first accelerates, then moves with a constant velocity and finally decelerates to stop. The maximum and minimum weight recorded are 80 kg and 64 kg respectively. Find out the true weight of that person considering g = 10 m/s^2

(a) 70 kg (b) 85 kg

(c) 72 kg (d) 65 kg

TS EAMCET 06.08.2021, Shift-II

Ans. (c) :



While Accelerating,	While decelerating,
$N_2 - ma = mg$	$N_1 + ma = mg$
$N_2 = mg + ma$	$N_1 = mg - ma$
$80g = mg + ma$ .....(i)	$64g = mg - ma$ .....(ii)

Adding equation (i) and (ii)

$$144\,g = 2mg$$

$$\boxed{m = 72kg}$$

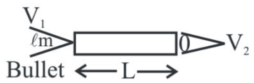
101. A bullet of mass m enters a wooden block of length L at a speed v_1 and emerges out of block with a speed v_2. If $\overline{F}$ is the average force which impeded its motion (Assume uniform deceleration inside the block)

(a) $\overline{F} = \frac{m}{2L}(v_2^2 - v_1^2)$ (b) $\overline{F} = \frac{m}{4L}(v_2^2 + v_1^2)$

(c) $\overline{F} = 2\frac{m}{L}(v_2 - v_1)^2$ (d) $\overline{F} = \frac{m}{2L}(v_2 + v_1)^2$

TS EAMCET 06.08.2021, Shift-I

Ans. (a) :



Given, distance traveled (s) = L

v_1 = Initial velocity

v_2 = Final velocity

@apna_pdf

From third equation of motion,

$$v^2 = u^2 + 2as$$

$$v_2^2 = v_1^2 + 2aL$$

$$2aL = v_2^2 - v_1^2$$

$$a = \frac{v_2^2 - v_1^2}{2L}$$

Here 'a' is retardation of bullet,

Then, Force F = ma

$$F = \frac{m\left(v_2^2 - v_1^2\right)}{2L}$$

102. Find the position of the particle which starts from rest at time t = 10 s. given the force acting on the particle with a mass of 50 g is $\left(5\hat{i} + 10\hat{j}\right)$N

(a) $\left(10000\hat{i} + 5000\hat{j}\right)$m

(b) $\left(5000\hat{i} + 5000\hat{j}\right)$m

(c) $\left(5000\hat{i} + 10000\hat{j}\right)$m

(d) $\left(10000\hat{i} + 10000\hat{j}\right)$m

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (c) : Given,

$$\vec{F} = 5\hat{i} + 10\hat{j}$$

Mass (m) = 50 g = 50 × 10^{-3} kg

Time (t) = 10 s

We know that,

$$\vec{F} = m\vec{a}$$

$$5\hat{i} + 10\hat{j} = 50 \times 10^{-3} \times a$$

$$\vec{a} = 100\hat{i} + 200\hat{j}$$

From second equation of motion

$$S = ut + \frac{1}{2}at^2$$

$$S = 0 \times 10 + \frac{1}{2}\left(100\hat{i} + 200\hat{j}\right) \times (10)^2$$

$$S = \frac{1}{2}\left(100\hat{i} + 200\hat{j}\right) \times 100$$

$$S = \left(5000\hat{i} + 10000\hat{j}\right)\text{m}$$

103. An object of mass 15 kg moves at a constant speed of 15 ms^{-1}. A constant force, which acts for 5 seconds on the object gives it a speed 5 ms^{-1} in opposite direction. The force acting on the object is?

(a) – 50 N (b) 60 N

(c) – 40 N (d) – 60 N

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (d) : Given, v_1 = 15 m/sec

v_2 = –5 m/sec (opposite direction)

Time (t) = 5sec

Mass (m) = 15 kg

We know force is equal to rate of change of momentum.

$$\vec{F} = m\frac{d\vec{v}}{dt}$$

$$\vec{F} = 15 \times \frac{[(-5) - 15]}{5}$$

$$\vec{F} = 15 \times \frac{-20}{5}$$

$$\boxed{\vec{F} = -60\text{N}}$$

104. A car moving at a speed 'v' is stopped by a retarding force 'F' in a distance 's'. If the retarding force were 3F. The car will be stopped in a distance ———.

(a) $\frac{s}{3}$ (b) $\frac{s}{6}$

(c) $\frac{s}{9}$ (d) $\frac{s}{12}$

AP EAMCET-24.08.2021, Shift-I

Ans. (a) : Let the mass of car be m

Retardation (a) = $\frac{-F}{m}$

Now using $v^2 - u^2 = 2as$, here final velocity is zero,

We get,

$$-u^2 = 2\frac{-F}{m}s$$

$$u^2 = \frac{2Fs}{m} \Rightarrow v^2 = \frac{2Fs}{m} \qquad \text{....(i)}$$

Now the force be 3F

Let the distance be s_1

Retardation $(a) = \frac{-3F}{m}$ velocity is v, final velocity,

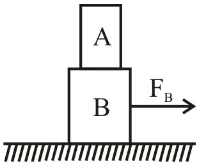
$$v^2 = 2\frac{3F}{m}s_1 \qquad \text{...(ii)}$$

From (i) & (ii)

$$\frac{2Fs}{m} = 2\frac{3F}{m}s_1$$

$$\Rightarrow s_1 = \frac{s}{3}$$

105. Two blocks A and B of masses 4 kg and 6 kg are as shown in the figure. A horizontal force of 12 N is required to make A slip over B. Find the maximum horizontal force F_B that can be applied on B so that both A and B move together (take g = 10 m.s^{-2})



(a) 30 N (b) 27 N

(c) 32 N (d) 25 N

AP EAMCET-19.08.2021, Shift-II

Ans. (a) : Given that–

m_A = 4 kg, f_A = 12N

m_B = 6 kg

@apna_pdf

$f_A = ma \Rightarrow a = \frac{f}{m_A} = \frac{12}{4} \Rightarrow a = 3\,m/s^2$

Now, when blocks move together the acceleration will be same–

Then, $F_B - f_A = m_B a$ ...(i)

$F_B - 12 = 6 \times 3$

$F_B = 18 + 12$

$F_B = 30$ N

106. An object is moving with a constant speed along a straight-line path. A force is not required to ________.

(a) increase its speed

(b) decrease its momentum

(c) change its direction

(d) keep it moving with uniform velocity

AP EAMCET-23.08.2021, Shift-II

Ans. (d) : When an object is moving with a constant speed along a straight line path. It mean velocity is uniform. Hence, no force is required to keep it moving with uniform velocity.

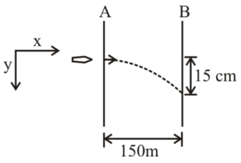
107. Two paper screens A and B are separated by 150 m. A bullet pierces A and then B. The hole in B is 15 cm below the hole in A. If the bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is: (g= 10 ms^{-2})

(a) $100\sqrt{3}$ m.s^{-1} (b) $200\sqrt{3}$ m.s^{-1}

(c) $300\sqrt{3}$ m.s^{-1} (d) $500\sqrt{3}$ m.s^{-1}

AP EAMCET-20.08.2021, Shift-II

Ans. (d) :



We know that,

$$s = ut + \frac{1}{2}at^2$$

Applying along y-direction,

$$15 \times 10^{-2} = \frac{1}{2}(10)t^2 \qquad (\because u_y = 0)$$

$$t^2 = \frac{30}{1000} = \frac{3}{100}$$

$$t = \frac{\sqrt{3}}{10}\text{sec.}$$

Now, along x-direction,

Distance = velocity × time

$$150 = u_x \times \frac{\sqrt{3}}{10}$$

$$u_x = 500\sqrt{3} \text{ m/s}$$

108. A bullet of mass 30 g moving with 700 ms^{-1} collides with a block of mass 4 kg hanging by a string of length 0.4 m. After collision, the block rises to a height of 0.2 m. Then find the velocity of the bullet when it comes out of the block ____.

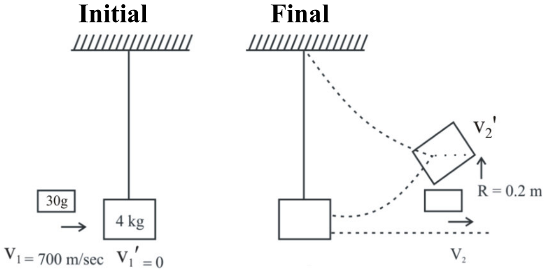
(a) 200 m.s^{-1} (b) 433 m.s^{-1}

(c) 400 m.s^{-1} (d) 332 m.s^{-1}

AP EAMCET-25.08.2021, Shift-II

Ans. (b) : Given, $m_1 = 30$ g$= 30 \times 10^{-3}$kg

$m_2 = 4$ kg, $v_1 = 700$ m/s and $v_2 = ?$



According to Newton's law of motion,

$$v^2 = u^2 + 2gh$$

$$(0)^2 - (v_2')^2 = 2gh$$

$$-v_2'^2 = 2(-10) \times 0.2$$

$$v_2' = \sqrt{4}$$

$$v_2' = 2 \text{ m/sec}$$

By conservation of momentum

$$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$

$$\frac{30}{1000} \times v_1 + 4 \times v_1' = \frac{30}{1000}v_2 + 4 \times v_2'$$

$$\frac{30}{1000} \times 700 + 4 \times 0 = \frac{30}{1000}v_2 + 4 \times 2$$

$$\frac{30}{10} \times 7 + 0 = \frac{30}{1000}v_2 + 8$$

$$21 = \frac{3v_2}{100} + 8$$

$$13 = \frac{3}{100}v_2$$

$$1300 = 3v_2$$

$$v_2 = \frac{1300}{3} = 433.33 \approx 433 \text{ m/sec.}$$

109. A gun fires bullets of mass 10 g each with a velocity of 750 m/s. This person holding the gun feels an average force of 150N against the gun. What is the rate of maximum number of bullets fired?

(a) 1250/min (b) 800/min

(c) 250/min (d) 1200/min

TS EAMCET 29.09.2020, Shift-I

Ans. (d) : Given,

Mass of bullet (m) = 10g = 0.01 kg

Velocity of bullet = 750 m/s

Force (f) = 150 N

Let the number of bullet be x

$$F = \frac{n\Delta p}{\Delta t}$$

$$150 = \frac{nmdv}{dt}$$

@apna_pdf

$$\frac{150}{m \times dv} = \frac{n}{dt}$$

$$\frac{150}{0.01 \times 750} = \frac{n}{1}$$

$$n = 20$$

Now, number of bullet per minute = 20 × 60 = 1200 bullet/min.

110. The velocity of an object of mass 2 kg is given by $v = \left(8t\hat{i} + 3t^2\hat{j}\right)$m/s, where t is time in seconds. What will be the direction of net force on the object relative to the positive direction of X-axis, at the instant when its magnitude is 20N?

(a) $\tan^{-1}\left(\frac{1}{2}\right)$ (b) $\tan^{-1}\left(\frac{2}{3}\right)$

(c) $\tan^{-1}\left(\frac{4}{5}\right)$ (d) $\tan^{-1}\left(\frac{3}{4}\right)$

TS-EAMCET.14.09.2020, Shift-2

Ans. (d) : Given that, m = 2 kg, $v = 8t\hat{i} + 3t^2\hat{j}$,

$|\vec{F}| = 20$ N

We know that, $\vec{F} = m\vec{a}$

$$\vec{a} = \frac{d\vec{v}}{dt} = 8\hat{i} + 6t\hat{j}$$

$$\vec{F} = 2\left(8\hat{i} + 6t\hat{j}\right)$$

$$\vec{F} = 16\hat{i} + 12t\,\hat{j}$$

$\therefore$ $20^2 = 16^2 + (12t)^2$

$$t = \sqrt{\frac{400 - 256}{144}} = 1 \text{ sec}$$

$\therefore$ $\vec{F} = 16\hat{i} + 12\hat{j}$

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$

$\therefore$ $\theta = \tan^{-1}\left(\frac{12}{16}\right)$

$\therefore$ $\theta = \tan^{-1}\left(\frac{3}{4}\right)$

111. A lift is tied with thick iron ropes having mass 'M'. The maximum acceleration of the lift is 'a' m/s^2 and maximum safe stress is 'S' N/m^2. The minimum diameter of the rope is (g = acceleration due to gravity)

(a) $\left[\frac{2M(g+a)}{\pi S}\right]^{\frac{1}{2}}$ (b) $\left[\frac{2M(g-a)}{\pi S}\right]^{\frac{1}{2}}$

(c) $\left[\frac{4M(g+a)}{\pi S}\right]^{\frac{1}{2}}$ (d) $\left[\frac{4M(g-a)}{\pi S}\right]^{\frac{1}{2}}$

MHT-CET 2020

Ans. (c) : We know that,

Force, F = m(g + a)

Stress × area = M (g + a) $\left[\because \text{Stress} = \frac{\text{Force}}{\text{area}}\right]$

$$S \times \pi \frac{d^2}{4} = M(g+a)$$

$$d^2 = \frac{4M(g+a)}{S\pi}$$

$$d = \left(\frac{4M(g+a)}{S\pi}\right)^{\frac{1}{2}}$$

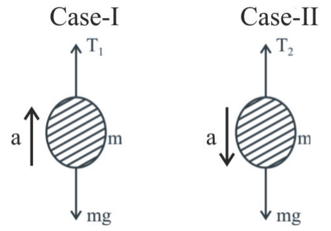
112. A mass of 1kg is suspended by a string. It is first lifted up with an acceleration of 4.9 m/s^2 and then lowered down with same acceleration. The ratio of tensions in the string in the two cases, respectively is g = 9.8 m/s^2

(a) 1:3 (b) 2:1

(c) 3:1 (d) 1:2

MHT-CET 2020

Ans. (c) : We know,



$ma_1 = T_1 - mg$ $ma_2 = mg - T_2$

$a_1 = a_2 = 4.9$ m/s^2

$g = 9.8$ m/s^2

$m = 1$ kg

Case-I

$T_1 - mg = ma_1$

$T_1 = m(g + a_1)$

$T_1 = 1\,(9.8 + 4.9)$

$T_1 = 14.7$N

Case-II

$ma_2 = mg - T_2$

$T_2 = m(g - a_2)$

$T_2 = 1\,(9.8 - 4.9)$

$T_2 = 4.9$N

$$\therefore \text{Ratio} = \frac{T_1}{T_2} = \frac{14.7}{4.9} = \frac{3}{1}$$

$T_1 : T_2 = 3 : 1$

113. A lift of mass 'm' is ascending with an acceleration 'a' (a < g). The tension in the cable of the lift is (g = acceleration due to gravity)

(a) m (a-g) (b) m (g-a)

(c) m (2g+a) (d) m (g+a)

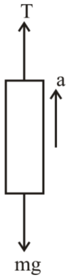
MHT-CET 2020

@apna_pdf

Ans. (d) : Given:

Mass of lift = m

Acceleration = a



Where, $a < g$

So,

Tension on cable of the lift will be

$T - mg = ma$

(Where 'g' is the acceleration due to gravity)

$T = mg + ma$

$\therefore \quad T = m(g + a)$

114. Pick out the correct statement

(a) Second law of motion is a vector equation
(b) Second law of motion is applicable to a particle and not to the system of particles
(c) Force is always in the direction of motion
(d) If external force on a body is zero, it does not mean the acceleration is zero
(e) Acceleration at an instant depends on the history of the motion of the particle

Kerala CEE 2020

Ans. (a) : $\vec{F} = m\vec{a}$ (Second law of motion)

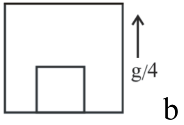
In this case, force $\vec{F}$ refers to the total external force on the system (internal forces in the system are not included in $\vec{F}$) and a refers to the acceleration of the whole system, i.e., acceleration of the centre of mass of the system.

115. A boy is standing on a weighing machine inside a lift. When the lift goes upwards with acceleration $\frac{g}{4}$, the machine shows the reading 50 kg. wt. When the lift goes downward with acceleration $\frac{g}{4}$, the reading of the machine in kg. wt. would be

(a) 50 (b) 30
(c) 45.5 (d) 62.5
(e) 14

Kerala CEE 2020

Ans. (b) : • Lift goes upwards,

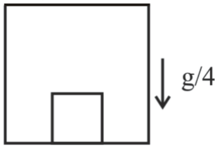


$$\Rightarrow \quad 50 \times g = m\left(g + \frac{g}{4}\right)$$

$$50g = m\left(\frac{5g}{4}\right)$$

$$m = 40 \text{ kg}$$

• Lift goes downward,



$$\Rightarrow \quad F_{net} = m\left(g - \frac{g}{4}\right)$$

$$= 40\left(\frac{3g}{4}\right)$$

$$= 30 \text{ N}$$

116. A ship of mass 2×10^7 kg initially at rest is pulled by a force of 5×10^5 N through a distance of 2m. Assuming that the resistance due to water is negligible, the speed of the ship is

(a) 2 ms^{-1} (b) 0.01 ms^{-1}
(c) 0.1 ms^{-1} (d) 1 ms^{-1}
(e) 5 ms^{-1}

Kerala CEE 2020

Ans. (c) : Given,

$m = 2 \times 10^7$ kg

$F = 5 \times 10^5$

Acceleration of the ship, applying Newton's law i.e., F = ma

$$a = \frac{F}{m} = \frac{5 \times 10^5}{2 \times 10^7} = \frac{5}{2} \times 10^{-2} \text{ m/s}^2$$

Final Speed of the ship,

Using 3rd equation of motion

$$v^2 - u^2 = 2as$$

$$v^2 - 0^2 = 2 \times \frac{5}{2} \times 10^{-2} \times 2$$

$$v = 0.1 \text{ m/s}$$

117. A force of $(2\hat{i} + 3\hat{j})$N acts on a body of mass 1 kg which is at rest initially. The acceleration of the body is

(a) $(4\hat{i} + 6\hat{j})\text{ms}^{-2}$ (b) $(2\hat{i} + 3\hat{j})\text{ms}^{-2}$
(c) $(3\hat{i} + 5\hat{j})\text{ms}^{-2}$ (d) $(6\hat{i} + 2\hat{j})\text{ms}^{-2}$
(e) $(\hat{i} + \hat{j})\text{ms}^{-2}$

Kerala CEE 2020

Ans. (b) : According to Newton's laws of motion,

$$F = ma \Rightarrow a = \frac{F}{m}$$

Here, $F = (2\hat{i} + 3\hat{j})$N

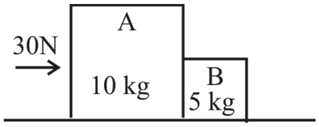
$m = 1$kg

then, $$a = \frac{(2\hat{i} + 3\hat{j})}{1}$$

$$a = (2\hat{i} + 3\hat{j})\text{ms}^{-2}$$

@apna_pdf

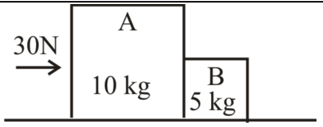
118. A constant horizontal force $\vec{F}$ of 30 N is applied to block A of mass 10 kg which pushes against block B of mass 5 kg. What is the net force on the block A? The block are placed on a frictionless table.



(a) 20 N
(b) 15 N
(c) 10 N
(d) 5 N

TS EAMCET 29.09.2020, Shift-II

Ans. (a) :



Since, the surface is frictionless, both the blocks will moves with a common acceleration.

Acceleration, $a = \frac{F_{net}}{m_{total}}$ $[F_{net} = 30\text{ N}, m_{total} = 15\text{ kg}]$

$$a = \frac{30}{(10+5)}$$
$$= \frac{30}{15}$$
$$= 2\text{m/s}^2$$

For, block A

$$\overset{A}{\boxed{10\text{kg}}} \rightarrow a = 2\text{ m/s}^2$$

Then, Net force on the block 'A'

$(F_{net})_A = m_A.a$
$= 10\times2$
$= 20\text{ N}$

Also for block 'B'

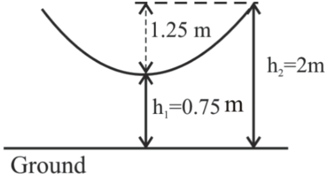
$(F_{net})_B = m_B.a$
$= 5\times2$
$= 10\text{N}$

119. The minimum and maximum heights attained by a child on a swing from the ground are 0.75 m and 2 m respectively. Find his/her maximum speed:

(a) 10 m.s^{-1}
(b) 5 m.s^{-1}
(c) 8 m.s^{-1}
(d) 15 m.s^{-1}

AP EAMCET-25.09.2020, Shift-I

Ans. (b) : From energy conservation,



From energy conservation,

$$\frac{1}{2}mv_{max}^2 = mg(h_2 - h_1)$$
$$v_{max} = \sqrt{2g(h_2 - h_1)}$$
$$= \sqrt{2\times10(2-0.75)} = 5\text{m/s}$$

120. At a metro station, a girl walks up a stationary escalator in 20s. If she remains stationary on the escalator, then the escaltor take her up in 30s. The time taken by her to walk up on the moving escalator will be :

(a) 25 s
(b) 60 s
(c) 12 s
(d) 10 s

Karnataka CET-2020

Ans. (c) : Given,

Let distance = h
Walking time = 20 sec
Escalator time = 30 sec

Speed of girl $(v_g) = \frac{h}{20}$

Speed of escalator $(v_e) = \frac{h}{30}$

Time taken by girl when she walk upon the moving escalator is

$$t = \frac{h}{v_g + v_e} \Rightarrow t = \frac{h}{\frac{h}{20} + \frac{h}{30}}$$
$$= \frac{20\times30}{(30+20)}$$
$$= 12\text{ sec}$$

121. A gun applies a force F on a bullet which is given by F = (100 – 0.5×10^{5}t)N. The bullet emerges out with speed 400 m/s. Then find out the impulse exerted till force on bullet becomes zero.

(a) 0.2 N-s
(b) 0.3 N-s
(c) 0.1 N-s
(d) 0.4 N-s

AIIMS-25.05.2019(M) Shift-1

Ans. (c) : Given, $F = (100 - 0.5 \times 10^5 t)\text{N}$

Impulse = $\int_0^t F dt$

Now, time t at which F = 0 is,

$$0 = 100 - 0.5 \times 10^5 t$$
$$t = 2 \times 10^{-3}$$

$$\therefore \text{Impulse} = \int_0^{2\times10^{-3}} (100 - 0.5\times10^5 t)dt$$
$$= \left[100t - \frac{0.5\times10^5 t^2}{2}\right]_0^{2\times10^{-3}}$$
$$= \left[100\times2\times10^{-3} - \frac{0.5\times10^5\times4\times10^{-6}}{2}\right]$$
$$= \left[200\times10^{-3} - \frac{2}{2\times10}\right]$$
$$= \left[\frac{200}{1000} - \frac{1}{10}\right] = \left[\frac{2}{10} - \frac{1}{10}\right]$$
$$= \frac{1}{10}$$

Impulse = 0.1 N–s.

@apna_pdf

122. The linear momentum of a particle moving in X – Y plane under the influence of a force is given as $\vec{P}(t) = A(\hat{i}\cos bt - \hat{j}\sin bt)$ where A and b are constant. The angle between the force and momentum is

(a) 0° (b) 45°
(c) 60° (d) 90°

UPSEE 2019

Ans. (d) : Given,

$$\vec{P} = A\left(\hat{i}\cos bt - \hat{j}\sin bt\right)$$

$$\vec{F} = \frac{d\vec{p}}{dt} = \frac{d}{dt}A\left(\hat{i}\cos bt - \hat{j}\sin bt\right)$$

$$\vec{F} = Ab\left[-\hat{i}\sin(bt) - \hat{j}\cos(bt)\right]$$

Angle between two vector is θ

$$\cos\theta = \frac{F.P}{|F|.|P|}$$

$$\cos\theta = \frac{Ab\left(-\hat{i}\sin bt - \hat{j}\cos bt\right)A\left(\hat{i}\cos bt - \hat{j}\sin bt\right)}{|F|.|P|}$$

$$\cos\theta = \frac{A^2b\left(-\sin bt.\cos bt + \sin bt.\cos bt\right)}{|F|.|P|}$$

$\therefore$ cos θ = 0

$\Rightarrow$ cos θ = cos 90º

$\Rightarrow$ θ = 90º

123. Two objects of mass m each moving with speed u m/s collide at 90°, then final momentum is (assume collision is inelastic)

(a) mu (b) 2 mu
(c) $\sqrt{2}$ mu (d) $2\sqrt{2}$ mu

JIPMER-2019

Ans. (c) : Given,
Speed of objects = u m/s
Since, both object collide with 90º
According to law of conservation of momentum,
Total momentum before collision = Total momentum after collision

$$P_i = P_f$$

$$\left|mu\,\hat{i} + mu\,\hat{j}\right| = P_f$$

$$\sqrt{m^2u^2 + m^2u^2} = P_f$$

$$P_f = \sqrt{2}mu$$

124. A soccer ball is travelling at a velocity 20 ms^{-1} due south. At the end of its travel, it moves with a velocity 2 ms^{-1} due south. If the change in the linear momentum of the ball is 18 kgms^{-1} due north, then the mass of the ball is

(a) 3.0 kg (b) 0.81 kg
(c) 1.0 kg (d) 0.5 kg

AP EAMCET-23.04.2019, Shift-II

Ans. (c) : Given,

$$\vec{v}_1 = (-20\hat{j})\text{ m/s}$$

$$\vec{v}_2 = (-2\hat{j})\text{ m/s}$$

$$\text{and } \Delta\vec{p} = (18\hat{j})\text{ kg m/s}$$

We know that,

$$p = mv$$

$$\Delta\vec{p} = p_f - p_i$$

$$\Delta\vec{p} = mv_2 - mv_1$$

$$18\hat{j} = m[-2\hat{j} - (-20\hat{j})]$$

$$18\hat{j} = m(18\hat{j})$$

$$m = 1\text{kg}$$

125. A body is acted on by a force given by F = (15 + 3t^2) N. The impulse received by the body during the first 2 seconds is

(a) 28 Ns (b) 38 Ns
(c) 30 Ns (d) 19 Ns

AP EAMCET (22.04.2019) Shift-II

Ans. (b) : Given, F = (15+3t^2), t = 2 s

On integrating, Impulse = $\int_0^t F dt$

$$= \int_0^t \left(15 + 3t^2\right)dt$$

$$= \left[15t + \frac{3t^3}{3}\right]_0^2$$

$$= 15(2) + (2)^3$$

$$= 30 + 8 = 38\text{ Ns}$$

126. Assertion: Mass is a measure of inertia of the body in linear motion.
Reason: Greater the mass, greater is the force required to change its state of rest or of uniform motion.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (a) : According to Newton's 2nd law of motion

$a = \frac{F}{m}$ i.e. magnitude of the acceleration produced by a given force is inversely proportional to the mass of the body. Higher is the mass of the body lesser will be the acceleration produced i.e. mass of the body is a measure of the opposition offered by the body to change a state. When the force is applied i.e. mass of a body is the measure of its inertia.

127. Assertion: When the lift moves with uniform velocity the man in the lift will feel weightlessness.
Reason: In downward accelerated motion of lift, apparent weight of a body increases.

@apna_pdf

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (d) : For uniform motion,

Apparent weight = Actual weight

For downward accelerated motion,

Apparent weight < Actual weight

For upward accelerated motion,

Apparent weight > Actual weight

128. An object with mass 5 kg is acted upon by a force, $\mathbf{F} = \left(-3\hat{i} + 4\hat{j}\right)$ N. If its initial velocity at t = 0 is $v = \left(3\hat{i} + 12\hat{j}\right)$ m/s, the time at which it will just have a velocity along y-axis is :

(a) 5 s
(b) 10 s
(c) 2 s
(d) 15 s

Karnataka CET-2019

Ans. (a) : Mass of object (m) = 5 kg

$$F = \left(-3\hat{i} + 4\hat{j}\right)\text{N}$$

Initial velocity at t = 0

$$u = v = \left(3\hat{i} + 12\hat{j}\right)\text{m/s}$$

If object have a velocity along y-axis then $v_x = 0$

∴ Acceleration along x- direction

$$a_x = \frac{F_x}{m} = \frac{-3}{5}$$

∴ From equation of motion

$$v_x = u_x + a_x t$$

$$0 = 3 - \left(\frac{3}{5}\right)t$$

t = 5sec

129. A vehicle moving at 36 km/hr is to be stopped by applying brakes in the next 5 m. If the vehicle weight 2000 kg, determine the average force that must be applied on it

(a) 10^4 N
(b) 2×10^4N
(c) 3×10^4N
(d) 5×10^3N
(e) 10^3N

Kerala CEE-2019

Ans. (b) : Given,

$$u = 36 \text{ km/hr} = 36\times\frac{5}{18} \text{ m/s} = 10 \text{ m/s}$$

Acceleration of vehicle = – a

m = 2000kg.

By third equation of motion,

$$v^2 - u^2 = 2as$$

$$\Rightarrow 0^2 - u^2 = -2as$$

$$a = \frac{u^2}{2s} = \frac{(10)^2}{2\times5}$$

$a = 10 \text{ m/s}^2$

The average force for braking,

F = ma

F = 2000×10

$F = 2 \times 10^4$ N

130. A ball of mass 0.45 kg which is initially at rest is hit by a bat. The bat remains in contact with the ball for 3×10^{-3}s. During this time period the force on the ball by the bat is given as $F(t) = \left[\left(\alpha\times10^6\right)t - \left(\beta\times10^9\right)t^2\right]$N where α and β are constants. The ball's speed, immediately as it loses contact with the bat is 20 m/s. The correct relation between α and β as

(a) $\alpha - 2\beta = 2$
(b) $\alpha + 2\beta = 2$
(c) $\alpha - \beta = 2$
(d) $2\alpha - \beta = 2$

TS EAMCET 08.05.2019, Shift-II

Ans. (a) : Given that,

mass, m = 0.45 kg

Time, $t = 3 \times 10^{-3}$ sec

Initial velocity, u = 0

Final velocity, v = 20 m/sec

We know that,

Impulse = Change in momentum

$$mv - mu = \int F(t)dt$$

$$0.45\times20 - 0.45\times0 = \int\left[\left(\alpha\times10^6\right)t - \left(\beta\times10^9\right)t^2\right]dt$$

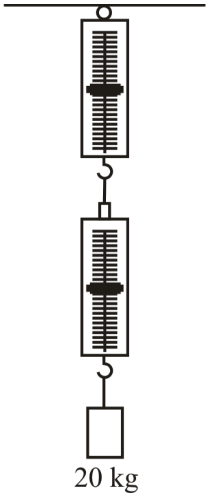
$$9 = \alpha \times 10^6 \times \frac{t^2}{2} - \beta\times10^9\times\frac{t^3}{3}$$

$$9 = \alpha\times10^6\times\frac{9\times10^{-6}}{2} - \beta\times10^9\times\frac{27\times10^{-9}}{3}$$

$$9 = \frac{9\alpha}{2} - 9\beta$$

$$\frac{\alpha}{2} - \beta = 1$$

131. A block of mass 20 kg is suspended through two spring balance with negligible mass as shown in figure. What will be the readings in the upper and lower balance respectively?



(a) 0 kg, 20 kg
(b) 10 kg, 20 kg
(c) 20 kg, 10 kg
(d) 10 kg, 10 kg
(e) 20 kg, 20 kg

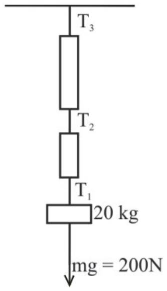
Kerala CEE-2019

@apna_pdf

Ans. (e) : Given,

Mass of block = 20 kg

And spring balances as negligible mass.



So, $T_1 = 200$ N

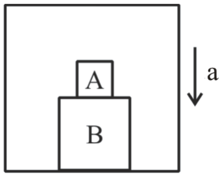
$T_2 = 200$ N

$T_3 = 200$ N

i.e. tension in both suspended balances is same.

Hence, the reading of upper and lower balance is 20 kg.

132. An elevator is descending (see the figure below) with a uniform acceleration. If the force exerted by the block A on, block B is 4 N, what is the acceleration of the lift, if the mass of the block A is 1/2 kg



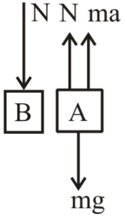
(a) 0.5 m/s^2 (b) 1 m/s^2

(c) 2 m/s^2 (d) 4 m/s^2

Assam CEE-2018

Ans. (c) : Given, $m_A = 0.5$ kg, N = 4N

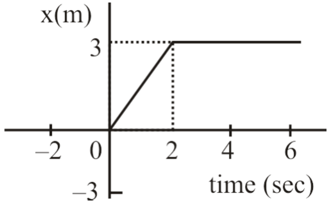
As it is descending downwards, then the pseudo force will act in upword direction,



$$mg - N = ma$$

$$a = \frac{mg - N}{m} = \frac{0.5\times10-4}{0.5} = \frac{1}{0.5} = 2m/s^2$$

133. Figure represents the position-time graph of a body of mass 4 kg. Impulse (kg ms^{-1}) imparted to the body at t = 0 is



(a) 6 (b) 4

(c) 3 (d) 0

AMU-2018

Ans. (a) : Given,

mass of body = 4 kg

v = slope of position-time graph,

From the graph,

$$v = \frac{3}{2} m/s$$

Now, impulse change in linear momentum

= m.v

$$= 4\times\frac{3}{2} = 6 kg\, m/s$$

134. If a car accelerates from 20 m/s to 40 m/s in 10 s and its forward thrust is equal to 3kN, what is the mass of car?

(a) 1500 tones (b) 150 tones

(c) 15 tones (d) 1.5 tones

SRM JEE-2018

Ans. (d) : Given,

u = 20 m/s

v = 40 m/s

t = 10 sec

f = 3 kN

$$a = \frac{v-u}{t}$$

$$= \frac{40-20}{10}$$

$a = 2\ ms^{-2}$

F = 3 kN = 3000N

F = ma

3000 = m × 2

m = 1500 kg = 1.5 Tones.

135. A machine gun has a mass 5 kg. It fires 50 gram bullets at the rate of 30 bullets per minute at a speed of 400 ms^{-1}. What force is required to keep the gun in position?

(a) 10N (b) 5N

(c) 15N (d) 30N

VITEEE-2018

Ans. (a) : Given that,

mass of gun (M) = 5 kg.

mass of bullets (m) = 50 g

$m = 50 \times 10^{-3}$ kg.

Speed (v) = 400 m/s

$$\text{No. of bullets in 60 sec.} = \frac{N}{t}$$

$$= \frac{30}{60}$$

$$= \frac{1}{2}\ \text{bullet/sec.}$$

By Newton's second law of motion

$$F = \frac{\Delta P}{\Delta t}$$

$$F = \frac{N}{t}\times\frac{mv}{\Delta t}$$

$$F = \frac{1}{2}\times\frac{50\times10^{-3}\times400}{1}$$

$= 25 \times 10^{-3} \times 400$

$= 100 \times 10^{2} \times 10^{-3}$

$= 1 \times 10^{4} \times 10^{-3}$

F = 10 N

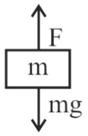
@apna_pdf

136. A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of 5m/s^2, the reading of the spring balance will be

(a) 49 N (b) 24 N
(c) 74 N (d) 15 N

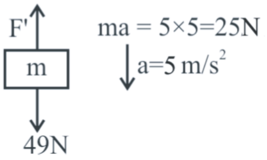
Manipal UGET-2018

Ans. (b) : When lift is stationary then, F = mg



$$\therefore \quad 49 = mg = m\times 9.8$$
$$m = 5kg$$

When lift is accelerating downward with acceleration (a) = 5 m/s^2



$$\therefore \quad F' + 25 = 49$$
$$F' = 49 - 25$$
$$F' = 24\,N$$

137. A boy, sitting on the topmost birth in the compartment of a train which is just going to stop on the railway station, drops an apple aiming at the open hand of his brother situated vertically below his own hand at a distance of 2 m. The apple will fall

(a) in the hand of his brother
(b) slightly away from the hand of his brother in the direction of motion of the train
(c) slightly away from the hand of his brother opposite to the direction of motion of the train
(d) None of the above

AIIMS-26.05.2018(E)

Ans. (b) : The apple will force slightly away from the hand of his brother in direction of motion of the train due to inertia of motion. When train is just going to stop, the boy and his brother slows down with train but the apple which is in freefall continue to move with the same speed and therefore, falls slightly away from the hand in direction of motion of the train.

138. The three central concepts in Newtonian mechanics are

(a) Mass, motion and gravity
(b) Mass, motion and force
(c) Weight, speed and gravity
(d) Force, mass and acceleration

J&K-CET-2018

Ans. (b) : A branch of mechanics that deals with concepts of Newton's law of motion as distance, time and mass in a period of time are known as Newtonian mechanics.

139. If a particle moves in a curved path, it must have a component of acceleration

(a) Perpendicular to the mass
(b) Perpendicular to the gravity
(c) Perpendicular to the velocity
(d) Parallel to the velocity

J&K-CET-2018

Ans. (c) : When a particle moves in a curve or circular path always has acceleration towards inside of the curve or circle and its component of acceleration is perpendicular to the velocity.

140. Law that proves that different masses accelerate to the earth at the same rate, but with different forces is

(a) Newton's first law
(b) Newton's second law
(c) Newton's third law
(d) Combination of Newton's first and third law

J&K-CET-2018

Ans. (b) : Newton's seconds law proves that different masses accelerate to the earth at the same rate, but with different force.

141. Consider a ship traveling due east along the equator with velocity v$_0$. If southeastern wind blows at an angle of 'ϕ' to the equator with velocity 'v'. The wind velocity relative to the ship v' and the angle between the equator and the wind direction in the reference frame fixed to the slip are

(a) $v' = \sqrt{v_0^2 + v^2 + 2v_0 v\cos\phi}, \sin^{-1}\left(\dfrac{v\sin\phi}{v'}\right)$

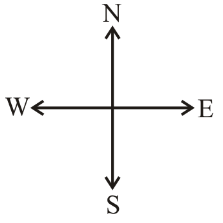
(b) $v' = \sqrt{v_0^2 + v^2 + 2vv_0 \sin\phi}, \cos^{-1}\left(\dfrac{v\cos\phi}{v'}\right)$

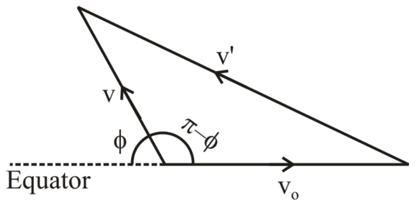
(c) $v' = \sqrt{v_0^2 + v^2 - 2v_0 v\cos\phi}, \sin^{-1}\left(\dfrac{v}{v'}\right)$

(d) $v' = v_0^2 + v^2 - 2v_0 v\cos\phi, \cos^{-1}\left(\dfrac{v}{v'}\right)$

TS EAMCET 02.05.2018, Shift-II

Ans. (a) :





$$\vec{v}_0 + \vec{v}' = \vec{v}$$
$$\vec{v}' = \vec{v} - \vec{v}_o$$

@apna_pdf

$$|\vec{v'}| = \sqrt{v_o^2 + v^2 - 2v_o v\cos(\pi - \phi)}$$

$$(\because \cos(\pi-\phi) = -\cos\phi)$$

$$v' = \sqrt{v_o^2 + v^2 + 2v_o v\cos\phi}$$

Let angle between the equator and the wind direction in the reference frame fixed to the ship is ϕ',

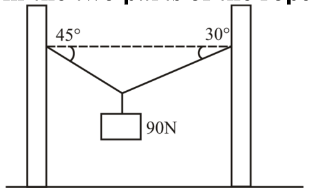
From sine law,

$$\frac{\sin\phi'}{v} = \frac{\sin(\pi-\phi)}{v'}$$

$$\sin\phi' = \frac{v}{v'}\sin\phi \qquad (\because \sin(\pi-\phi) = \sin\phi)$$

$$\phi' = \sin^{-1}\left(\frac{v\sin\phi}{v'}\right)$$

142. 90 N mass is hung on a rope tied between two poles as shown in the figure. The tension T_1 and T_2 in the two parts of the rope are (in N).

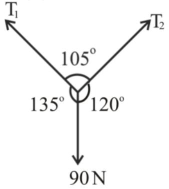


(a) $\frac{180}{\sqrt{3}+1}.\frac{\sqrt{6}}{2}, \frac{180}{\sqrt{3}+1}$ (b) $\frac{90}{\sqrt{3}+1}.\frac{\sqrt{6}}{2}, \frac{180}{\sqrt{3}}$

(c) $\frac{180}{\sqrt{3}+1}.\frac{\sqrt{3}}{2}, \frac{90}{\sqrt{3}+1}$ (d) $\frac{90}{\sqrt{3}+1}.\frac{\sqrt{3}}{2}, \frac{90}{\sqrt{3}}$

TS EAMCET (Medical)-02.05.2018, Shift-I

Ans. (a) : F.B.D of the given figure,



Applying Lami's theorem,

$$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin 135°} = \frac{90}{\sin 105°}$$

$$\frac{T_1}{\frac{\sqrt{3}}{2}} = \frac{T_2}{\frac{1}{\sqrt{2}}} = \frac{90}{\sin(60°+45°)}$$

We know, sin(A + B) = sinAcosB + cosAsinB

sin (60° + 45°) = sin 60° cos 45° + cos 60° sin 45°

$$= \frac{\sqrt{3}}{2}\times\frac{1}{\sqrt{2}} + \frac{1}{2}\times\frac{1}{\sqrt{2}} \quad = \frac{1}{2\sqrt{2}}(\sqrt{3}+1)$$

$$\frac{T_1}{\frac{\sqrt{3}}{2}} = \frac{T_2}{\frac{1}{\sqrt{2}}} = \frac{90}{\frac{1}{2\sqrt{2}}(\sqrt{3}+1)}$$

$$\because T_1 = 90\times\frac{\sqrt{3}}{2}\times\frac{2\sqrt{2}}{\sqrt{3}+1}$$

$$T_1 = \frac{180}{\sqrt{3}+1}\times\frac{\sqrt{6}}{2}$$

$$\text{and, } T_2 = \frac{90}{\sqrt{2}}\times\frac{2\sqrt{2}}{\sqrt{3}+1}$$

$$T_2 = \frac{180}{\sqrt{3}+1}$$

143. If a stone of mass 0.05 kg is thrown out a window of a train moving at a constant speed of 100 km/h then magnitude of the net force acting on the stone is

(a) 0.5 N (b) zero

(c) 50 N (d) 5 N

BITSAT-2018

Ans. (a) : Net force acting on stone when it is thrown out of the window is only force due to the gravity.

$$\therefore \quad F = mg = 0.05\times 10 = 0.5\text{N}$$

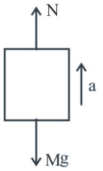
144. A lift moves vertically up with an acceleration a. Force exerted by a person of mass M on the floor of the lift is

(a) Ma (b) Mg

(c) M(g + a) (d) M (g – a)

J&K-CET-2017

Ans. (c) :



Using Newton's second law-

Ma = N – Mg

N = M(g + a)

∴ Force exerted by a person of mass M on the floor of the lift.

N = M(g + a)

145. Consider the following statements in the context of forjmulation of any law of Physics

I. explain the existing physical facts

II. no need of experimental verification

III. predict future results

Then, any formulated law of Physics, should be true with respect to:

(a) I and II (b) II and III

(c) I and III (d) I,II and III

TS EAMCET(Medical)-2017

Ans. (c): In the context of formulation of any law of physics, the law of physics can give a valid explanation about the existing physical facts and using appropriate equations derived from law of physics, can be used to predict the future results.

146. A man of mass 60 kg climbed down using an elevator. The elevator had an acceleration 4 ms^{-2}. If the acceleration due to gravity is 10 ms^{-2}, the man's apparent weight on his way down is

(a) 60 N (b) 240 N

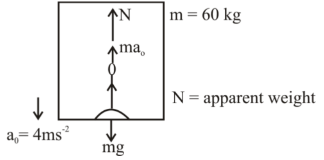
(c) 360 N (d) 840 N

(e) 3600 N

Kerala CEE - 2017

@apna_pdf

Ans. (c) : Given, m = 60 kg, $a_0 = 4$ m/s^2
With respect to the frame of reference of elevator,



$$\sum F = 0$$

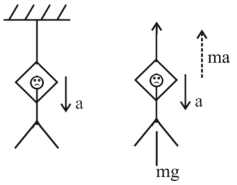
$$N + ma_0 = mg$$

N = m (g–a_0)
N = 60 (10–4) = 60×6
N = 360 N

147. A man weighing 100 kg slides down a light rope with an acceleration of 1.8 ms^{-2}. If g = 9.8 ms^{-2}, the tension of the rope is
(a) 180 N (b) 1160 N
(c) 800 N (d) weightlessness

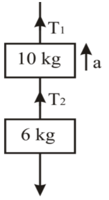
Manipal UGET-2017

Ans. (c) : Given, mass of man (m) = 100 kg
acceleration = 1.8 m/s^2



We know that,
∴ T + ma = mg
T = m(g – a)
T = 100 (9.8 – 1.8) = 800 N
Hence, the tension of the rope is 800N

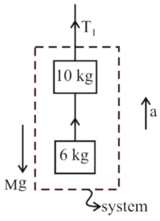
148. A body of mass 6 kg is hanging from another body of mass 10 kg as shown in figure. This combination is being pulled up by a string with an acceleration of 2 ms^{-2}. The tension T_1 is, (g = 10 ms^{-2})



(a) 240 N (b) 150 N
(c) 220 N (d) 192 N
(e) 178 N

Kerala CEE - 2010

Ans. (d) : Given,
$m_1 = 10$ kg
$m_2 = 6$ kg
mass of system, M = $m_1 + m_2$

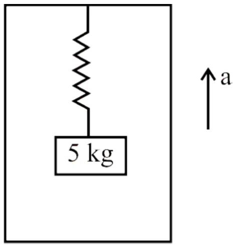


T_1 = M (g + a)
Tension is pulling the mass (M = 10 + 6 = 16 kg)
T_1 = (10 + 6) (10 + 2)
T_1 = 192 N

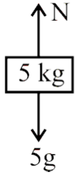
149. An object of mass 5 kg is attached to the hook of a spring balance and the balance is suspended vertically from the roof of a lift. The reading on the spring balance when the lift is going up with an acceleration of 0.25 ms^{-2} is taken (g = 10 ms^{-2})
(a) 51.25 N (b) 48.75 N
(c) 52.75 N (d) 47.25 N
(e) 55 N

Kerala CEE - 2008

Ans. (a) : Given that,
m = 5 kg
a = 0.25 m/s^2



Let N be the reading on spring Balance-



Force will be equal to the weight-
Weight = mg + ma
= m(g + a)
Weight = 5(10 + 0.25)
∴ = 51.25 N

150. Physical independence of force is a consequence of:
(a) third law of motion
(b) second law of motion
(c) first law of motion
(d) all of these laws
(e) none of the above

Kerala CEE 2004

Ans. (c) : Newton 1st law of motion states that when a body of mass 'm' moving with acceleration 'a', then the mathematical value of force acting on the body is product of mass and acceleration.
So, 1st law of motion show physical independency of force as force is independent of mass and acceleration.

151. Which of the following is NOT an illustration of Newton's third law?
(a) Flight of a jet plane
(b) A cricket player lowering his hands while catching a cricket ball
(c) Walking on floor
(d) Rebounding of a rubber ball

UPSEE - 2009

@apna_pdf

Ans. (b) : Newton third law says that every action has an equal and opposite reaction. So, bowler catching a ball moves his hand backward is an example of phenomenon under taken by momentum because while lowering his hand he is trying to slow down the ball to get a lesser effect of momentum.

152. A machine gun fires a bullet of mass 40 g with a velocity 1200 m/s. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can be fired per second at the most?

(a) Only one
(b) Three
(c) Can fire any number of bullets
(d) 144×48

UPSEE - 2008

Ans. (b) : Let, n = no. of bullet fired per second,

$$\therefore \quad F_{ext} = n\left[\frac{\Delta p}{\Delta t}\right]$$

Where, $\frac{\Delta p}{\Delta t}$ = Rate of change of momentum of each bullet.

$$F_{ext} = n\left[\frac{mv-0}{\Delta t}\right]$$

$$144 = n \times \frac{40 \times 1200 \times 10^{-3}}{1}$$

$$\therefore \quad n = \frac{144}{40 \times 1200 \times 10^{-3}}$$

$$n = \frac{144}{4 \times 12}$$

$$n = 3$$

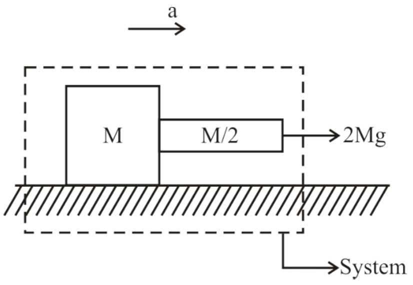
Hence, number of bullet fired per second = 3

153. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass M/2. If a force 2 Mg is applied at one end of the rope, the force which the rope exerts on the block is–

(a) 2 Mg/3
(b) 2Mg
(c) 4Mg/3
(d) zero

BITSAT-2009

Ans. (c) :



We know that, $F_{Ext} = Ma$

$$2Mg = \left(M + \frac{M}{2}\right)a \quad \left[\because \text{Total mass} = M + \frac{M}{2}\right]$$

$$\frac{2Mg}{\frac{3M}{2}} = a \qquad [\because F = 2\ mg]$$

$$a = \frac{4g}{3}$$

Force applied on the block (F) = Ma = $M \times \frac{4g}{3} = \frac{4Mg}{3}$

154. The laws of Newton's are applicable

(a) in rotatory frame
(b) in inertial frame
(c) in non-inertial frame
(d) in accelerated frame

CG PET- 2012

Ans. (b) : Laws of Newton are applicable in an inertial frame of reference. In non-inertial frame laws of Newton can be applied by applying pseudo force on the body.

155. The fundamental Newton's law of motions is

(a) F=ma
(b) F= 0 if a =0
(c) $F_{12} = -F_{21}$
(d) $F = \frac{d}{dt}(mv)$

CG PET- 2011

Ans. (d) : Fundamental Newton's laws of motion is

$$F = \frac{d}{dt}(mv) \qquad [\because P = mv]$$

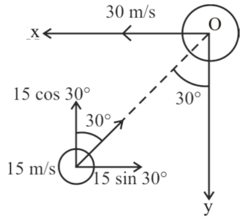
i.e. net force on a system is equal to rate of change of momentum. Second and third laws can be generated from this law.

156. A hockey player receives a corner shot at a speed of 15 m/s at an angle of 30° with the y-axis and then shoots the ball of mass 100 g along the negative x-axis with a speed of 30m/s. If it remains in contact with the hockey stick for 0.01 s, the force imparted to the ball in the x-direction is

(a) 281.25 N
(b) 187.5 N
(c) 562.5 N
(d) 375 N

Manipal UGET-2010

Ans. (d) : Given,
Angle made with y-axis (θ) = 30°
Mass of ball = 100×10^{-3} kg
Time to connect = 0.01 sec
Initial velocity (u) = 15 m/s
Final velocity (v) = 30 m/s



From Newton's second law of motion,

$$F = \frac{\Delta P}{\Delta t}$$

or $$F = \frac{m(v-u)}{t} \qquad \ldots(i)$$

According to the question, along x-direction = u sin 30°

@apna_pdf

$$F = \frac{100\times10^{-3}\left[30-\left(-15\sin30^{\circ}\right)\right]}{0.01}$$

$$= \frac{100\times10^{-3}\left[30+15\times\frac{1}{2}\right]}{0.01}$$

$$= \frac{100\times10^{-3}\left[30+7.5\right]}{0.01} = \frac{10^{2}\times10^{-3}\times37.5}{0.01}$$

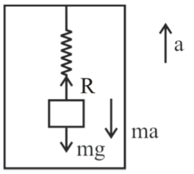
F = 375 N

157. A mass is hanging on a spring balance which is kept in lift. The lift ascends. The spring balance will show in its readings

(a) an increase
(b) a decrease
(c) no change
(d) a change depending on its velocity

AIIMS-2014

Ans. (a) : Let, acceleration = a, reaction at spring = R



$\therefore$ $R = mg + ma$

So, reading of spring balance increases due to net weight increase.

158. When a horse pulls a wagon, the force that causes the horse to move forward is the force

(a) the ground exerts on it
(b) it exerts on the ground
(c) the wagon exerts on it
(d) it exerts on the wagon

AIIMS-2010

Ans. (a) : According to the Newton's 3rd law of motion, When a horse pulls a wagon, the force that causes the horse to move forward is the force the ground exerts on it which have same magnitude.

159. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2. He reaches the ground with a speed of 3 m/s. At what height, did he bail out?

(a) 182 m (b) 91 m
(c) 111 m (d) 293 m

AIIMS-2008

Ans. (d) : Given, speed (v) = 3 m/s, decelerates (a) = 2m/s^2, height (s) = 50 m

Let H be height when parachutist bails out,

When parachute is close-

According to Newton 3rd law of motion

$$v^2 = u^2 + 2as$$

When parachutist bails out, u = 0

So, $v'^2 = 2(-9.8)(-50)$

$$v'^2 = 2\times9.8\times50$$

$$v' = 14\sqrt{5}\ \text{m/s}$$

When parachute is open-

$$u = v' = 14\sqrt{5}\ \text{m/s}$$

$$v^2 = u^2 + 2as$$

$$\frac{v^2-u^2}{2a} = s$$

$$s = \frac{3^2-\left(14\sqrt{5}\right)^2}{2\times2} = -242.75 \approx 243\ \text{m}$$

$\therefore$ H = 243 + 50 = 293m

160. A person is standing in an elevator. In which situation he finds his weight less?

(a) When the elevator moves upward with constant acceleration
(b) When the elevator moves downward with constant acceleration
(c) When the elevator moves upward with uniform velocity
(d) When the elevator moves downward uniform velocity

AIIMS-2005

Ans. (b) : When the lift moves downwards with acceleration 'a' then net downwards force on the person is,

$$mg - R = ma$$

$\therefore$ Apparent weight, $R = mg - ma$
$= m(g-a)$

Here, R = m(g – a) is the resultant weight, while is less than the original weight mg.

Therefore, person will feel his weight less when the lift moves downward with constant acceleration.

161. The velocity of a bullet is reduced from 200 m/s to 100 m/s while travelling through a wooden block of thickness 10 cm. Assuming it to be uniform, the retardation will be:

(a) 15×10^4 m/s^2 (b) 10×10^4 m/s^2
(c) 12×10^4 m/s^2 (d) 14.5 m/s^2

AIIMS-2001

Ans. (a) : Given that, u = 200 m/s, v = 100 m/s, s = 10 cm = 0.1 m

We know that,

$$v^2 = u^2 + 2as$$

$$(100)^2 = (200)^2 + 2\times a\times0.1$$

$\therefore$ $a = 15\times10^4\ \text{m/s}^2$ (Retardation)

162. Impulse of a force is equal to the change in-

(a) mass (b) velocity
(c) momentum (d) energy

BCECE-2014

Ans. (c) : From

$$\text{Force, } F = \frac{dp}{dt}$$

$$\int_{t_1}^{t_2} F\,dt = \int_{P_1}^{P_2} dp$$

$$\text{Impulse, } I = [P]_{P_1}^{P_2}$$

$I = P_2 - P_1 = \Delta P$ = change in momentum.

163. A ship of mass 3 × 10^7 kg, initially at rest, is pulled by a force of 5 × 10^4 N through a distance of 3m. Assuming that the resistance due to water is negligible, the speed of the ship is–

@apna_pdf

(a) 1.5 m/s (b) 60 m/s
(c) 0.1 m/s (d) 5 m/s

BCECE-2010

Ans. (c) : Given that,
Mass, m = 3 × 10^7 kg
F = 5 × 10^4 N
Distance (s) = 3 m
We know that,
Force (F) = ma

$$\text{Acceleration, } a = \frac{F}{m} = \frac{5\times10^4}{3\times10^7} m/s^2$$

$$\Rightarrow \quad a = \frac{5}{3}\times10^{-3} m/s^2$$

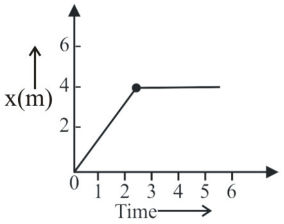
$$\text{Since,} \quad v^2 - u^2 = 2as$$

$$v^2 - 0 = 2\times\frac{5}{3}\times10^{-3}\times3$$

$$v^2 = 10^{-2}$$

$$v = 0.1 m/s$$

164. In the adjoining figure, the position time graph of a particle of mass 0.1kg is shown. The impulses at t=2s is



(a) 0.02kgm/s (b) 0.1 kg m/s
(c) 0.2 kg m/s (d) 0.4kg m/s

VITEEE-2013

Ans. (c) : From the graph we can say upto t = 2s, the body moves with a constant velocity

$$\text{Slope of position, time graph velocity (v)} = \frac{4}{2} = 2 m/s$$

After t = 2s, position time graph is parallel to time axis.
∴ Change in velocity (dv) = 2 m/s
Impulse = change in momentum = mdv
= 0.1 × 2
= 0.2 kgm/s

165. A body of mass 4 kg is accelerated upon by a constant force, travels a distance of 5 m in the first second and a distance of 2 m in the third second. The force acting on the body is :
(a) 2 N (b) 4 N
(c) 6 N (d) 8 N

Karnataka CET-2008

Ans. (c) : Distance travelled by the body in n^{th} second is given by,

$$S_n = u + \frac{a}{2}(2n-1)$$

For first second, distance = 5 m and n = 1

$$5 = u + \frac{a}{2}(2\times1-1)$$

$$5 = u + \frac{a}{2} \qquad \text{.........(i)}$$

For the third second, distance = 2m and n = 3

$$2 = u + \frac{a}{2}(2\times3-1)$$

$$2 = u + \frac{5}{2}a \qquad \text{.........(ii)}$$

Subtracting equation (ii) from (i)
a = –1.5 m/s^2
We know that,
F = ma
F = 4 × (–1.5)
F = –6N
The negative sign indicate there is deacceleration.

166. A student unable to answer a question on Newton's laws of motion attempts to pull himself up by tugging on his hair. He will not succeed :
(a) as the force exerted is small
(b) the frictional force while gripping, is small
(c) Newton's law of inertia is not applicable to living beings
(d) as the force applied is internal to the system

Karnataka CET-2005

Ans. (d) : According to Newton's first law of motion, the state of rest or motion of a body in a straight line with uniform velocity remains the same unless an external force is applied on the body.

167. A very large number of balls are thrown vertically upwards in quick succession in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute is :
(take g = 10 m/s^2)
(a) 80 (b) 120
(c) 40 (d) 60

Karnataka CET-2002

Ans. (d) : Given that,
Maximum height gained by ball is 5m
H = 5m
Final velocity v = 0
Initial velocity of ball be u
$v^2 = u^2 - 2gH$
$0 = u^2 - 2gH$ [v=0]
$u = \sqrt{2gH} = \sqrt{2\times10\times5} = 10$
Time taken by ball to gain height H is
v = u – gt
0 = 10 – 10t
t = 1 sec
The time interval for balls between one another is 1sec.
So, 60 balls are thrown in one minute.

168. Rocket propulsion is associated with
(a) the conservation of angular momentum.
(b) the conservation of mass.
(c) the conservation of mechanical energy.
(d) Newton's III law of motion.

J&K CET- 2010

Ans. (d) : Rocket propulsion is associated with Newton's third law of motion. Newton's third law of motion, states that to every action there is always an equal and opposite reaction.

@apna_pdf

169. In case of a book lying on table

(a) action of book and reaction of table on book are equal and opposite and are inclined to vertical
(b) action and reaction are equal but act in the same direction
(c) action and reaction are equal and opposite and act perpendicular to the surface of contact
(d) action and reaction are not equal but act in opposite direction

J&K CET- 2001

Ans. (c) : A book lying on table because action and reaction are equal and opposite and act perpendicular to the surface of contact.

170. Newton's second law of motion is

(a) $F = \frac{dp}{dt}$ (b) $F = m\upsilon$
(c) $F = m\upsilon^2$ (d) $F = m^2\upsilon$

J&K-CET-2013

Ans. (a) : The rate of change of momentum of a body is directly proportional to the resultant force applied to the body and is in the same direction as the force.

$$F = \frac{dp}{dt}$$

171. A person is standing on a weighing-scale and observes that the reading is 60 kg. He then suddenly jumps up and observes that reading goes to 70 kg. Then his maximum upward acceleration is

(a) zero (b) 1.4 m/s^2
(c) 1.63 m/s^2 (d) 9.8m/s^2

J&K-CET-2015

Ans. (c) : Given that,
Initial reading of the machine is 60 kg
Mass of the person, m = 60 kg
Final reading = 70 kg

Thus,
Extra force applied on the person is
$\Delta F = (70 - 60) \times 9.8 = 98$ N

Hence, upward acceleration of the person is

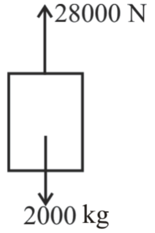
$$a = \frac{\Delta F}{m} = \frac{98}{60} = 1.63\,m/s^2$$

172. The mass of a lift is 2000 kg. When the tension in the supporting cable is 28000 N, then its acceleration is

(a) 30 ms^{-2} downwards (b) 4 ms^{-2} upwards
(c) 4 ms^{-2} downwards (d) 14 ms^{-2} upwards

AIPMT- 2009

Ans. (b) : Given,
Mass of lift = 2000 Kg = 20000 N (downward)
Tension, T = 28000 N (upward)



Lift is accelerating upward at the rate of acceleration a

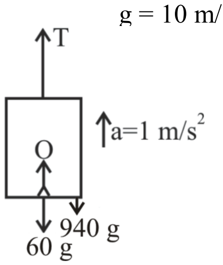
So, $R - mg = ma$
$28000 - 20000 = 2000\ a$
$a = 8000/2000$
$a = 4$ m/s^2 upward

173. A person of mass 60 kg is inside a lift of mass 940 kg and presses the button on control panel. The lift starts moving upwards with an acceleration 1.0m/s^2. If g =10m/s^2, the tension in the supporting cable is

(a) 9680 N (b) 11000 N
(c) 1200 N (d) 8600 N

AIPMT- 2011

Ans. (b) : Given,
Mass of person (m) = 60kg
Mass of lift (M) = 940kg
a = 1 m/s^2
g = 10 m/s^2



From figure,
Let tension in the supporting cable is T
Therefore,

$T - (M + m)g = (M + m)a$
$T = (60g + 940g) + (60 + 940)a$
$T = (1000 \times 10) + (1000 \times 1)$
$T = 10000 + 1000$
$T = 11000$ N

174. The average force that is necessary to stop a hammer with 25 Ns momentum in 0.05 s is

(a) 500 N (b) 125 N
(c) 50 N (d) 25 N

EAMCET-1991

Ans. (a): Given, momentum (p) = 25 Ns
time (t) = 0.05 s

We know,
Momentum (p) = F × t
F = p/t

$$F = \frac{25}{0.05}$$
$$= 500\ N$$

175. A gun fires 50 g bullets with velocity 1000 ms^{-1} each. The soldier holding the gun can exert an average force of 180 N against the gun. The maximum number of bullets, he can fire per minute is

(a) 216 (b) 300
(c) 156 (d) 276

EAMCET-1993

Ans. (a): Given that,
Mass of the bullet (m) = 50 g = 50×10^{-3} kg
Velocity of the bullet (v) = 1000 ms^{-1}
Average force (F) = 180 N

By taking momentum
p = mv

@apna_pdf

$p = 50 \times 10^{-3} \times 1000$

$p = 50$ kg m/s

Force on the man is equal to the change in momentum of the bullets coming out of the gun.

According to Newton's second law of motion

$$F = \frac{\Delta p}{\Delta t}$$

Here $\Delta t = 60$ second

$$F = \frac{50 \times n}{60}$$

$$180 = \frac{50 \times n}{60}$$

$$180 \times 60 = 50 \times n$$

$$10800 = 50 \times n$$

$$n = \frac{10800}{50}$$

$n = 216$ bullet

176. A gun is aimed at a target in line with its barrel. The target is released and allowed to fall under gravity, at the instant, the gun is fired. The bullet will

(a) pass above the target
(b) pass below the target
(c) hit the target
(d) certainly hit the target

EAMCET-1994

Ans. (c): At the instant when bullet and target are released. The vertical component of both will be same and both are under influence of gravitational acceleration and vertical downward displacement of both (target and bullet) will be equal.

177. A motor car of mass 300 kg is moving with a velocity of 25 ms^{-1}, by applying brakes the car was brought to rest in a distance of 15 m. The force of retardation in Newton is

(a) 2500 (b) 4500
(c) 6250 (d) 7500

EAMCET-1994

Ans. (c): Given that,

$m = 300$ kg, $u = 25$ ms^{-1}

$s = 15$ m $\quad v = 0$

From equation of motion

$v^2 = u^2 + 2as$

$0 = (25)^2 + 2 \times a \times 15$

$-30a = 625$

$$a = -\frac{625}{30} \text{ m/s}^2 \text{ (Retardation)}$$

Now, $F = m.a$

$$= 300 \times \frac{625}{30}$$

$= 6250$N

178. If a body in equilibrium under a set of non-collinear forces, the minimum number of forces has to be

(a) four (b) three
(c) two (d) five

EAMCET-1998

Ans. (b): If three non-collinear forces are acting on a body and the body is in equilibrium, then these forces can be represented by the sides of a triangle taken in order. Thus, minimum forces are three.

179. The weight of a man in a lift moving upwards is 608 N while the weight of the same man in the lift moving downwards, with the same acceleration is 368 N. His normal weight in Newton is

(a) 488 (b) 588
(c) 480 (d) 240

EAMCET-1997

Ans. (a): If the lift is moving upwards with acceleration a then, m (g + a) = 608 N ...(i)

If the lift is moving downwards with an acceleration a then,

$m(g - a) = 368$ N ...(ii)

Now, adding Equation (i) and (ii)

We get,

$2\,mg - ma + ma = 608 + 368$

$2\,mg = 608 + 368$

$2\,mg = 976$

$mg = 488$

180. The relation $\vec{F} = m\vec{a}$, cannot be deduced from Newton's second law, if

(a) force depends on time
(b) momentum depends on time
(c) acceleration depends on time
(d) mass depends on time

EAMCET-1998

Ans. (d): Newton second law of motion can be represented as

$F = m \times a$

Where F is the force

m is the mass of the object

a is the acceleration

The relation $\vec{F} = ma$, can only be deduced from Newton's second law, if mass remains constant with time. If mass depends on time then this relation cannot be deduced.

181. A book is kept on the surface of a table. If the gravitational pull of the earth on the book is the force of action, then the force of reaction is exerted by

(a) the book on the table
(b) the book on the earth
(c) the table on the book
(d) the table on the earth

NDA (II) 2009

Ans. : (c) Force of reaction is exerted by the table on the book it is based on Newton's third law of motion.

182. When a moving bus suddenly applies brakes, the passengers sitting in it fall in the forward direction. This can be explained by:

(a) The theory of relativity.
(b) Newton's first law
(c) Newton's second law

@apna_pdf

(d) Newton's third law

NDA (I) 2011

Ans. : (b) When a moving bus suddenly applies breaks, the passengers sitting in it fall in the forward direction. This can be explained by Newton's first law of motion.
Newton's first law of motion:- It is also called the law of inertia which states that if a body is at rest or moving at a constant speed in a straight line it will remain at rest or keep moving in a straight line at constant speed unless it is exerted by an external force.

183. A man is at rest in the middle of a horizontal plane of perfectly smooth surface of ice. He can move himself to the shore by making use of Newton's law:
(a) First law of motion.
(b) Second law of motion.
(c) Third law of motion.
(d) First, second and third laws of motion.

NDA (I) 2011

Ans. : (c) The man can move himself to the shore by using Newton's third law of motion which states that " When two bodies interact they apply forces to one another that are equal in magnitude and opposite in direction" Thus when the person pushes forward the reaction force offered by the we is very little but this reaction force will help to move forward.

184. One feels heavier in a lift when the lift
(a) is going down steadily
(b) just begins to go up
(c) is moving up steadily
(d) descends freely

NDA (II) 2012

Ans. (b) : When the lift just begins to go up one feels heavier because our body gains inertia from the position of rest and pushes up against the gravity. So, here the weight becomes zero and our mass makes up feel heavier.

185. The weight of an object may be assigned by using Newton's
(a) first law of motion
(b) second law of motion
(c) third law of motion
(d) laws of gravitation

NDA (II) 2013

Ans. (d) : The weight of an object may be assigned by using Newton's law of Gravitation which states that everybody in this universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F = \frac{Gm_1m_2}{r^2}$$

Where F is the force between masses
G→ Gravitational constant
r→ distance between them

186. A man is sitting in a train which is moving with a velocity of 60 km/hour. His speed with respect to the train is:
(a) 10/3 m/s (b) 60 m/s
(c) Infinite (d) zero

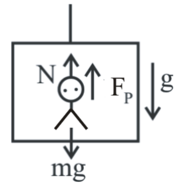
NDA (II) 2015

Ans. : (d) Since, man is sitting in the train and the train is moving with the speed of 60 km/hr. Therefore man is also moving in the same direction with same velocity as train.
Thus velocity of man (V_m) = Velocity of train (V_t) = 60 km/hr
∴ Velocity of man w.r.t train zero
$= V_m - V_t = 60 - 60 = 0$ km/hr

187. A man weighing 70 kg is coming down in a lift. If the cable of the lift breaks suddenly, the weight of the man would become
(a) 70 kg (b) 35 kg
(c) 140 kg (d) Zero

NDA (I) 2016

Ans. :(d) Given: Mass of man = 70kg
Free body diagram:- Here when the cable of the lift breaks then the lift will fall down with an acceleration of g. The man in the lift experiences a pseudo force in the opposite direction (upward).



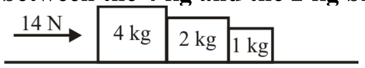
∴ Pseudo force on man in the upward direction,
$F_p = mg$
The original weight of the man in the downward direction,
$W = mg$
If N is the normal force by the surface of the lift on man then from free body diagram, $N + F_p = mg$
$\Rightarrow N = mg - F_p = mg - mg$
$\Rightarrow N = 0$ Thus weight of the man in lift would be zero.

188. A boy of mass 40 kg is climbing a vertical pole at a constant speed. If the coefficient of friction between his palms and the pole is 0.8 and g = 10 m/s^2, the horizontal force that he is applying on the pole is
(a) 300 N (b) 400 N
(c) 500 N (d) 600 N

WB JEE-2010

Ans. (c) : Given that, $\mu = 0.8$, $g = 10$ m/s^2
$m = 40$ kg
∵ $f = \mu N$
$mg = \mu N$
$$N = \frac{40\times10}{0.8}$$
$$N = \frac{4000}{8}$$
$N = 500$ N

189. Three blocks of masses 4 kg, 2 kg, 1 kg respectively are in contact on a frictionless table as shown in the figure. If a force of 14 N is applied on the 4 kg block, the contact force between the 4 kg and the 2 kg block will be

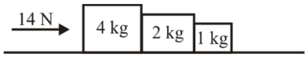


(a) 2 N (b) 6 N
(c) 8 N (d) 14 N

WB JEE 2012

@apna_pdf

Ans. (b):



Given:

$m_A = 4kg$

$m_B = 2kg$

$m_C = 1kg$

$F = 14N$

Total mass (m) = 4 + 2 + 1 = 7kg

Using Newton's second law,

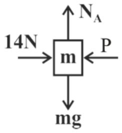
$F = ma$

$14 = 7a$

$a = 2m/s^2$

P be the force applied on block A by block B,

FBD of block A,



From Newton's second law,

$14 - P = 4a$

$14 - P = 4 \times 2$

$P = 14 - 8$

$P = 6N$

190. A box is moved along a straight line by a machine delivering constant power. The distance moved by the body in time is proportional to

(a) $t^{1/2}$ (b) $t^{3/4}$

(c) $t^{3/2}$ (d) t^2

WB JEE 2011

Ans. (c) : Let s be the distance moved by the body

Power, P = F.v

Force, F = m.a

$\because$ $v = s/t$

$a = s/t^2$

$P = [ms/t^2] \times [s/t]$

$s^2 = Pt^3/m$

From the above equation,

$s^2 \propto t^3$

$s \propto t^{3/2}$

191. A lift is moving downwards with an acceleration equal to acceleration due to gravity. A body of mass M kept on the floor of the lift is pulled horizontally. If the coefficient of friction is μ, then the frictional resistance offered by the body is

(a) Mg (b) μMg

(c) 2μMg (d) Zero

UP CPMT-2011

Ans. (d) : Let acceleration of lift be 'a'

N = Normal force on body acting up due to lift

m = mass of object

f = friction force

μ = coefficient of friction force

mg = force due to gravity acting on a body in a downward direction

ma = net force

g = acceleration of body in the downward body

According to question,

$a = g$ .....(i)

Net force, $ma = mg - N$ .....(ii)

From equation (i) and equation (ii) we get,

$N = mg - mg$

$N = 0$

$\because$ Friction force, $f = \mu N$

$f = \mu \times 0$

$f = 0$

192. A body of mass 0.1 kg attains a velocity of 10 ms^{-1} in 0.1s. The force acting on the body is

(a) 10 N (b) 0.01 N

(c) 0.1 N (d) 100 N

UP CPMT-2003

Ans. (a) : Given that,

Velocity (ΔV) = 10m/s

Mass (m) = 0.1 kg

Time (Δt) = 0.1 s

We know that,

Force (F) = m a

$$F = m \times \left(\frac{\Delta V}{\Delta t}\right)$$

$$F = 0.1 \times \frac{10}{0.1}$$

$$F = 10N$$

193. A body of mass 10 kg is acted upon by a force given by equation F = (3t^2 – 30) Newton's, The initial velocity of the body is 10m/s. The velocity of the body after 5 sec is

(a) 4.5m/s (b) 6 m/s

(c) 7.5m/s (d) 5 m/s

TS EAMCET (Engg.)-2015

Ans. (c) : Given that,

Mass of body, m = 10kg

$v_{t=0} = 10$ m/s

$v_{t=5} = ?$

$F = (3t^2 - 30)N$

$$\because \quad a = \frac{F}{m} = \left(\frac{3t^2 - 30}{10}\right) m/s^2$$

But, $a = \dfrac{dv}{dt}$

Taking integration on both side,

$$\int_0^5 a dt = \int_{10}^{v} dv$$

$$\int_0^5 \left(\frac{3t^2 - 30}{10}\right) dt = \int_{10}^{v} dv$$

$$\frac{1}{10}\int_0^5 (3t^2 - 30) dt = \int_{10}^{v} dv$$

$$\frac{1}{10}\left[t^3 - 30t\right]_0^5 = [v]_{10}^{v}$$

$$\frac{-25}{10} = v - 10$$

$v = 7.5$ m/s

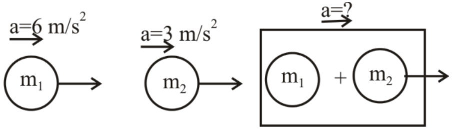
@apna_pdf

194. When a force F is applied to a mass m_1, its acceleration is 6 m/s^2. If the same force is applied to another mass m_2 it gives an acceleration 3 m/s^2. If the two masses are tied together and if the same force is applied to the combination it gives an acceleration

(a) 1 m/s^2 (b) 3 m/s^2
(c) 2 m/s^2 (d) 1.5 m/s^2

TS EAMCET(Medical)-2015

Ans. (c) : Given,



$F = m_1a$ $F = m_2a$ $F = (m_1+m_2)a$

$F = 6m_1$ ..(i) $F = 3m_2$ ..(ii) $a = \dfrac{F}{m_1+m_2}$ ...(iii)

From eq^n (i) and (ii), $m_1 = \dfrac{F}{6},\ m_2 = \dfrac{F}{3}$

Putting the value of m_1 and m_2 in equation (iii),

$$a = \frac{F}{\frac{F}{6}+\frac{F}{3}} = \frac{6}{1+2}$$

$$\Rightarrow a = \frac{6}{3} = 2 m/s$$

$$\alpha - 2\beta = 2$$

195. A 60 kg man pushes a 40 kg man by a force on 60 N. The 40 kg man has pushed the other man with a force of:

(a) 40 N (b) 0
(c) 60 N (d) 20 N

MP PET-2012

AP EAMCET-19.08.2021 Shift-I

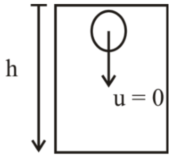
Ans. (c) : Newton's 3rd law states that every motion, there is equal and opposite reaction, which means action and reaction are equal and opposite. So, when 60 kg man exerts a force of 60 N on 40 kg man then 40 kg man also exerts the same force of 60 N on the 60 kg man.

196. A coin is dropped in a lift. It takes time t_1 to reach the floor when lift is stationary. It takes. Time t_2 when lift is moving up with constant acceleration. Then,

(a) $t_1 \geq t_2$ (b) $t_2 \geq t_1$
(c) $t_1 = t_2$ (d) $t_1 >> t_2$

JIPMER-2012

Ans. (a) : Case-Ist



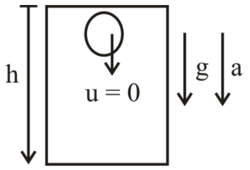
By second law of motion,

$$s = ut + \frac{1}{2}at^2$$

$$h = 0 + \frac{1}{2}g \times t_1^2$$

$$t_1 = \sqrt{\frac{2h}{g}}$$

Case-IInd



effective acceleration (a') = a + g

$$s = ut + \frac{1}{2}a't^2$$

$$h = 0 + \frac{1}{2}(a+g)t_2^2$$

$$t_2^2 = \frac{2h}{(a+g)}$$

$$t_2 = \sqrt{\frac{2h}{a+g}}$$

So, $t_1 > t_2$

197. A ball of mass 150 g moving with an acceleration 20 m/sec^2 is hit by force which acts on it for 0.1 sec. The impulsive force is

(a) 1.2 Ns (b) 0.3 Ns
(c) 0.1 Ns (d) 0.5 Ns

JIPMER-2004

Ans. (b) : Given data

Mass of ball (m) = 150 g

Acceleration (a) = 20 m/s^2

Time (Δt) = 0.1 sec

We know,

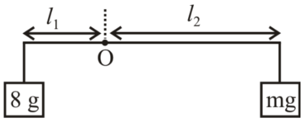
Impulsive force $= F \times t$
$= m \times a \times t$
$= 150 \times 10^{-3} \times 20 \times 0.1$
$= 0.3$ Ns

198. A body weighing 8 g when placed in one pan and 18 g when placed on the other pan of a false balance. If the beam is horizontal when both the pans are empty, then the true weight of the body is

(a) 13 g (b) 9 g
(c) 22 g (d) 12 g

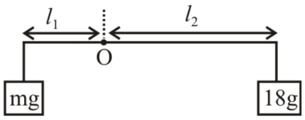
JIPMEER-2015

Ans. (d) :



Case–I, Taking moment point O,

$8g \times l_1 = mg \times l_2$ ....(i)



Case–II, again taking moment point O,

$18g\ l_2 = mg \times l_1$ ....(ii)

@apna_pdf

From equation (i) and (iii), we get

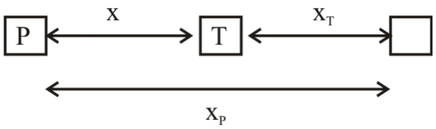
$$8g\times18g\times l_1 l_2 = (mg)^2 \times l_1 l_2$$
$$(mg)^2 = 144\,g^2$$
$$m=\sqrt{144}=12\text{kg}$$

199. A police party is moving in a jeep at a constant speed v. They saw a thief at a distance x on a motorcycle which is at rest. The moment the police saw the thief, the thief started at constant acceleration a. Which of the following relations is true if the police is able to catch the thief?

(a) $v^2 < ax$ (b) $v^2 < 2ax$
(c) $v^2 \geq 2ax$ (d) $v^2 = ax$

AP EAMCET -2011

Ans. (c) : If police is able to catch the thif after time t, then



$$\because x_P = x + x_T$$
$$vt = x + \frac{1}{2}at^2$$
$$at^2 - 2vt + 2x = 0$$
$$t=\frac{2v\pm\sqrt{4v^2-8ax}}{2a}$$
$$t=\frac{v\pm\sqrt{v^2-2ax}}{a}$$
$$\because \quad v^2 - 2ax \geq 0$$
$$v^2 \geq 2ax \qquad \text{For t to be real}$$

200. A force $(2\hat{i}+\hat{j}-\hat{k})$ N acts on a body, which is initially at rest. At the end of 20s the velocity of the body is $(4\hat{i}+2\hat{j}-2\hat{k})$ ms^{-1}, then the mass of the body is

(a) 8 kg (b) 10 kg
(c) 5 kg (d) 4.5 kg

AP EAMCET -2015

Ans. (b) : Given, dt = 20 sec

$$\vec{F}=\left(2\hat{i}+\hat{j}-\hat{k}\right)N, \vec{V}=\left(4\hat{i}+2\hat{j}-2\hat{k}\right)m/s$$

Now, $F=\sqrt{2^2+1^2+(-1)^2}=\sqrt{4+1+1}$

$$=\sqrt{6}\,N$$
$$\vec{V}=\left(4\hat{i}+2\hat{j}-2\hat{k}\right)m/s$$
$$V=\sqrt{4^2+2^2+(-2)^2}$$
$$=\sqrt{16+4+4}$$
$$V=\sqrt{24}=2\sqrt{6}\,m/s$$

We know that

$$F=m\frac{dv}{dt}\Rightarrow m=\frac{F.dt}{dv}=\frac{\sqrt{6}\times20}{v-u} \qquad (\because u=0)$$
$$m=\frac{\sqrt{6}\times20}{2\sqrt{6}}=10\text{kg}$$

201. Which one of the following statements regarding Newton's first law of motion is incorrect?

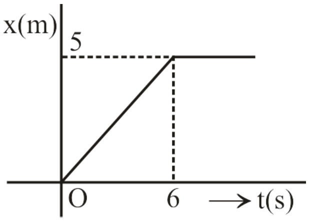
(a) It is an independent statement.
(b) It defines an inertial frame of reference.
(c) It was first enunciated by Galileo.
(d) It is a special case of Newton's second law.

AMU-2008

Ans. (a) : Newton's first law of motion is defined as an inertial frame of reference and it was enunciated by Galileo.

Inertia is a tendency of the object to resist change in its state. Newton's first law of motion also states similar object will remain in its present state unless an external force is applied. That's why Newton's first law is known as 'Law of Inertia'.

202. The position-time graph of a particle of mass 4 kg is shown in the figure. Calculate the impulse (in MKS units) at time t = 0 and t = 6 seconds respectively



(a) +6.31 and –6.31
(b) +3.33 and –3.33
(c) +5.25 and –5.25
(d) +3.25 and –3.25

AMU-2012

Ans. (b) : According to the graph,

At, t = 6 s at, t = 0 s

$$v_2=\frac{5}{6}m/s, \qquad v_1 = 0\ m/s$$

Now, Impulse = change in momentum

$$= m_1v_2 - m_2v_1$$
$$= 4\times\frac{5}{6}-4\times0$$
$$=\frac{20}{6}=3.33$$

203. A boy of mass 50 kg is standing on a weighing machine placed at the floor of a lift. The machine reads his weight in Newton's. What is the reading of the machine, if the lift is moving upwards with a uniform speed of 10 ms^{-1} (g = 10 ms^{-2})

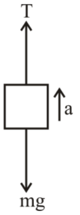
(a) 510 N (b) 480 N
(c) 490 N (d) 500 N

AP EAMCET(Medical)-2009

@apna_pdf

Ans. (d) : Given, mass of boy (m) = 50 kg

and v = 10 m/s



Acceleration (a) = 0

$F_{net} = 0$

Actual weight = mg

= 50 × 10 = 500 N

Hence option (d) is correct

204. The average resisting force that must act on a 5kg mass to reduce its speed from 65cm/s to 15cm/s in 0.2 s is:

(a) 12.5 N (b) 25 N
(c) 50 N (d) 100 N

AP EAMCET(Medical)-2000

Ans. (a) : From IInd law of motion,

$$F = \frac{m(v-u)}{dt} = \frac{5(65-15)}{0.2 \times 100} = \frac{5 \times 50}{20}$$

F = 12.5 N

Hence, the required average resisting force is 12.5 N

205. A constant force acts on a body of mass 0.9 kg at rest for 10s. If the body moves a distance of 250 m the magnitude of the force is:

(a) 3N (b) 3.5N
(c) 4.0N (d) 4.5N

AP EAMCET(Medical)-2000

Ans. (d) : Given,

Mass of a body (m) = 0.9 kg

Distance covered by body (s) = 250 m

t = 10s

From equation of motion,

$$s = ut + \frac{1}{2}at^2$$

$$250 = 0 + \frac{1}{2} \times a \times (10)^2$$

$$250 = \frac{1}{2} \times a \times 100$$

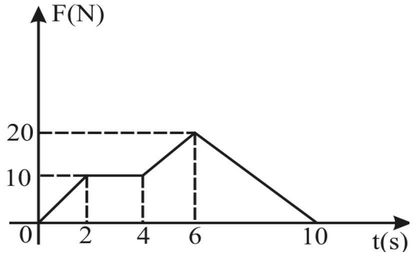
$$a = \frac{250 \times 2}{100}$$

$$a = 5\,m/s^2$$

Now, F = ma

F = 0.9 × 5 = 4.5 N

206. A particle of mass 2 kg is initially at rest. A force acts on it whose magnitude changes with time. The force time graph is shown below.



The velocity of the particle after 10 s is

(a) 20 ms^{-1} (b) 10 ms^{-1}
(c) 75 ms^{-1} (d) 26 ms^{-1}
(e) 50 ms^{-1}

Kerala CEE - 2008

Ans. (e) : Area under the F–t curve = change in momentum

Applying formulas and value of area from graph,

$$mv = \left(\frac{1}{2} \times 2 \times 10\right) + \left(\frac{1}{2} \times 4 \times 20\right) + (2 \times 10) + \left[\frac{1}{2} \times 2(10+20)\right]$$

2v = 10 + 40 + 20 + 30

2v = 100

v = 50ms^{-1}

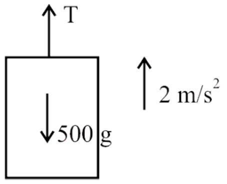
207. The mass of a lift is 500 kg. What will be the tension in its cable when it is going up with an acceleration of 2.0 m/s^2? (g=9.8m/s^2)

(a) 5000 N (b) 5600 N
(c) 5900 N (d) 6200 N

CG PET- 2004

Ans. (c) : Given,

Mass of a lift = 500 kg



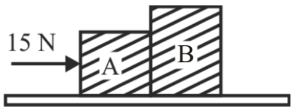
We know that,

T = m(g + a)

T = 500 (9.8 + 2) = 500 × 11.8

T = 5900 N

208. On a smooth plane surface (figure) two block A and B are accelerated up by applying a force 15 N on A. If mass of B is twice that of A, the force on B is

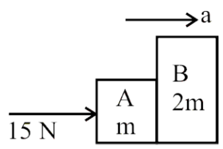


(a) 30 N (b) 15 N
(c) 10 N (d) 5 N

AIIMS-2012

@apna_pdf

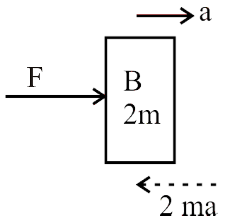
Ans. (c) :



$$\therefore F_{ext} = m_t a$$

$$15 = (m + 2m)a$$

$$a = \frac{15}{3m} = \frac{5}{m}$$



$$\therefore \quad F = 2ma$$

$$= 2m \times \frac{5}{m}$$

$$F = 10 \text{ N}$$

209. A force of 10 N acts on a body of mass 20 kg for 10 seconds. Change in its momentum is

(a) 5 kg m/s

(b) 100 kg m/s

(c) 200 kg m/s

(d) 1000 kg m/s

J&K CET- 1999

Ans. (b) : Given,

F = 10N

mass of body (m) = 20 kg

t = 10 sec

$\Delta p = F\Delta t$

$\Delta p = 10 \times 10$

$\Delta p = 100\text{Ns} = 100$ kg m/s

210. The impulse on a particle due to a force acting on it during a given time interval is equal to the change in its

(a) force

(b) momentum

(c) work done

(d) energy

NDA (I) 2016

Ans. (b) : According to impulse-momentum theorem, the change in momentum of a particle during a time interval is equal to the impulse of the net force acting on the particle during that interval.

211. A cricket ball of mass 0.25 kg with speed 10 ms^{-1} collides with a bat and returns with same speed within 0.01 s. The force acted on bat is

(a) 25 N (b) 50 N

(c) 250 N (d) 500 N

WB JEE 2011

Ans. (d) : Given,

Mass of the ball = 0.25 kg

Initial velocity (u) = – 10 m/s

Final velocity (v) = 10 m/s

$\Delta t = 0.01$ s

Now,

$$\Delta p = mv - mu$$

$$\Delta p = 0.25(10) - 0.25(-10) = 5 \text{ kgms}^{-1}$$

Force acting on bat, $F = \frac{\Delta p}{\Delta t} = \frac{5}{0.01} = 500\,\text{N}$

Hence, the force acted on bat is 500 N.

212. An object of mass 3 kg is at rest. If a force $F = (6t^2\hat{i} + 4t\hat{j})$ N is applied on the object, then the velocity of the object at t = 3 s is

(a) $18\hat{i} + 3\hat{j}$ (b) $18\hat{i} + 6\hat{j}$

(c) $3\hat{i} + 18\hat{j}$ (d) $18\hat{i} + 4\hat{j}$

AIPMT- 2002

Ans. (b) : Given, mass = 3 kg, t = 3s

$F = (6t^2\hat{i} + 4t\hat{j})$ N

we know that

$$\vec{F} = m\vec{a}$$

$$\vec{F} = m\frac{d\vec{v}}{dt}$$

$$d\vec{v} = \frac{\vec{F}}{m}dt$$

$$d\vec{v} = \frac{6t^2\hat{i} + 4t\hat{j}}{3}$$

$$\int_0^{\vec{v}} d\vec{v} = \frac{1}{3}\int_0^3 \left(6t^2\hat{i} + 4t\hat{j}\right)dt$$

$$\vec{v} = \frac{1}{3}\left[\frac{6t^3}{3}.\hat{i} + \frac{4t^2}{2}.\hat{j}\right]_0^3$$

$$= \frac{1}{3}\left[2\times(3)^3.\hat{i} + 2\times(3)^2.\hat{j}\right]$$

$$\therefore \vec{v} = 18\hat{i} + 6\hat{j}$$

@apna_pdf

(c) Law of Conservation of Momentum

213. A machine gun of mass 10kg fires 20 g bullets at the rate of 180 bullets per minute with a speed of 100 ms^{-1} each. The recoil velocity of the gun is :

(a) 0.6 m/s (b) 2.5 m/s
(c) 1.5 m/s (d) 0.02 m/s

JEE Main-30.01.2023, Shift-II

Ans. (a) : Given, Mass of machine gun (m_g) = 10 kg

Number of bullets fired per second = $\frac{180}{60} = 3$

Mass of bullets (m_b) = 3 × 20 gm = 60 × 10^{-3} kg

Velocity of bullets (v_b) = 100 m/s

According to the momentum conservation –

$$m_g v_g = m_b v_b$$
$$10 \times v_g = 60 \times 10^{-3} \times 100$$
$$v_g = 0.6 \text{ m/s}$$

214. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 ms^{-1}. The KE of the other mass is

(a) 256 J (b) 486 J
(c) 524 J (d) 324 J

Karnataka CET-2016
BCECE-2010
UPSEE - 2010
Manipal UGET-2010

Ans. (b) : Given, m_1 = 18 kg, v_1 = 6m/s, m_2 = 12 kg. Momentum is conserved just before and after the explosion of the bomb. Initial momentum is zero, so the resultant momentum of the exploded pieces should be zero.

$$m_1 v_1 = m_2 v_2$$
$$18 \times 6 = 12\, v_2$$
$$v_2 = 9 \text{ m/s}$$

$\therefore$ KE of 12 kg mass $K_2 = \frac{1}{2} m_2 v_2^2$

$$= \frac{1}{2} \times 12 \times 9 \times 9 = 486\text{J}$$

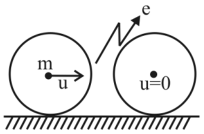
215. In the motion of a rocket, physical quantity which is conserved is:

(a) angular momentum (b) linear momentum
(c) force (d) work
(e) energy

J&K CET- 2009, 1998
CG PET- 2004
Kerala CEE- 2004

Ans. (b): Rocket works on the principle of conservation of momentum. Rocket ejaculates gases in backward direction which creates momentum of the gases backwards and thus by conservation of momentum, the rocket gets momentum in the forward direction making it move forward. Thus the rocket works on the principle of conservation of linear momentum.

216. A sphere of mass m moving with a constant velocity u hits another stationary sphere of the same mass and of coefficient of restitution (e). The ratio of velocities of the two spheres, after collision will be



(a) $\frac{1-e}{1+e}$ (b) $\frac{e}{e+1}$
(c) 2/e (d) $\frac{e+1}{2e}$

Manipal UGET-2016
JCECE-2015
AP EMCET(Medical)-2010

Ans. (a) : Given that,

Mass of first sphere (m_1) = m
Mass of second sphere (m_2) = m
Velocity of first sphere (u_1) = u
Velocity of second sphere (u_2) = 0

Let v_1 and v_2 be their velocities

After collision-

From law of conservation of momentum-

$$mu = m(v_1 + v_2)$$

or $u = v_1 + v_2$ …(i)

By definition,

$$e = \frac{v_2 - v_1}{u_2 - u_1}$$
$$e = \frac{v_2 - v_1}{u - 0}$$

or , $v_2 - v_1 = eu$ ….(ii)

Solving equation (i) and (ii) , we have

$$v_1 = \frac{(1-e)u}{2}$$

And $v_2 = \frac{(1+e)}{2}u$

$$\therefore \quad \frac{v_1}{v_2} = \frac{1-e}{1+e}$$

217. A ball of mass 0.5 kg moving horizontally at 10 ms^{-1} strikes a vertical wall and rebounds with speed V. The magnitude of the change in linear momentum is found to be 8.0 kg ms^{-1}. The magnitude of V is

(a) 6.0 ms^{-1} (b) 9.0 ms^{-1}
(c) 26.0 ms^{-1} (d) 13.0 ms^{-1}

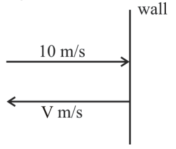
AP EAMCET-04.07.2022, Shift-I

Ans. (c) : Given, initial velocity (v_i) = 10 m/s

Final velocity (v_f) = V

Mass of ball (m) = 0.5 kg

And change in momentum = 8 kg m/s



@apna_pdf

Then,

Change in momentum = $P_f - P_i$

$P_i = m v_i = 0.5 \times 10 = 5$

$P_f = m v_f = 0.5 \times V = 0.5V$

$8 = 0.5V - 5$

$0.5V = 13$

$V = 26$ m/s

218. A block of mass 8 kg is suspended by a rope of length 3m from the ceiling. A force of 40 N is applied horizontally to the block. Then the angle that the rope makes with the vertical in equilibrium is
(acceleration due to gravity = 10 ms^{-2}, neglect the mass of the rope)

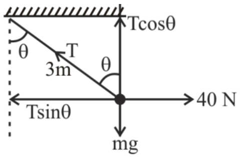
(a) $\sin^{-1}\frac{1}{2}$ (b) $\tan^{-1}\frac{1}{2}$

(c) $\sin^{-1}\frac{1}{3}$ (d) $\tan^{-1}\frac{1}{3}$

AP EAMCET-08.07.2022, Shift-I

Ans. (b) : Given, mass (m) = 8 kg = 80 N

Length of the rope = 3 m



Let θ angle make by the rope with vertical for equilibrium–

From the figure,

$\sum F_x = 0$

$T\sin\theta = 40$ …(i)

And

$\sum F_y = 0$

$T\cos\theta = mg$

$T\cos\theta = 80$ …(ii)

From equation (i) / (ii), we get–

$$\frac{T\sin\theta}{T\cos\theta} = \frac{40}{80}$$

$$\tan\theta = \frac{40}{80}$$

$\theta = \tan^{-1}(1/2)$

219. A car of mass 1800 kg travelling north at 30 kmh^{-1} turns east and accelerates to 40 kmh^{-1}. The magnitude of the change in its momentum in kg m s^{-1} is

(a) 5000 (b) 25000

(c) 10000 (d) 20000

AP EAMCET-12.07.2022, Shift-I

Ans. (b) : Given, mass of car (m) = 1800 kg

$v_1 = 30\,\hat{j}$ km/h and $v_2 = 40\,\hat{i}$ km/h

Magnitude of change in velocity is,

$$|\Delta v| = \sqrt{(v_1)^2 + (v_2)^2}$$

$$= \sqrt{(30)^2 + (40)^2} = \sqrt{2500} = 50\,\text{km/hr}$$

So, magnitude of change in linear momentum is,

$$|\Delta\vec{p}| = m\,|\Delta v|$$

$$= 1800 \times 50 \times \frac{1000}{3600} = 25000\,\text{kg m/s}$$

220. A cricket ball of mass 50 g having velocity 50 cm s^{-1} is stopped in 0.5 s. The force applied to stop the ball is

(a) 0.07 N (b) 0.05 N

(c) 5 N (d) 7 N

AP EAMCET-04.07.2022, Shift-II

Ans. (b) :

Given, Mass of the ball (m) = 50g $= \frac{50}{1000} = 0.05$kg

Velocity of the ball = 50 cm/s = 0.5 m/s

Time = 0.5 s

Momentum of ball before stopping= mv = 0.05 × 0.5

= 0.025 kg m/s

Momentum of ball after stopping = 0

Force applied to stop the ball = $\frac{\text{change in momentum}}{\text{time}}$

$$= \frac{0.025 - 0}{0.5} = 0.05\text{ N}$$

221. A boy of mass M at rest explodes into three pieces, in the ratio of masses 1 : 1 : 2. Two smaller pieces fly off perpendicular to each other with velocities of 30 ms^{-1} and 40 ms^{-1} respectively. The velocity of the third piece will be

(a) 15 ms^{-1} (b) 25 ms^{-1}

(c) 35 ms^{-1} (d) 50 ms^{-1}

JEE Main-29.06.2022, Shift-I

Ans. (b) : Let, mass 'M' is divided in three

Pieces two of which has mass $\frac{M}{4}$ each.

$M_1 = M_2 = \frac{1}{4}$ and $M_3 = \frac{2}{4} = \frac{1}{2}$

∴ Two pieces of equal mass fly off perpendicular

$$(M_1V_1)^2 + (M_2V_2)^2 = (M_3V_3)^2$$

$$\left(\frac{1}{2}\times V_3\right)^2 = \left(\frac{1}{4}\times 30\right)^2 + \left(\frac{1}{4}\times 40\right)^2$$

$$\frac{1}{4}V_3^2 = \frac{1}{16}\left[(30)^2 + (40)^2\right]$$

$$v_3^2 = \frac{1}{4}[900 + 1600]$$

$$V_3^2 = \frac{1}{4}\times 2500$$

$$V_3 = \frac{1}{2}\times 50$$

$$V_3 = 25\,\text{m/sec}$$

@apna_pdf

222. A fighter jet is flying horizontally at a certain altitude with a speed of 200 ms^{-1}. When it passes directly overhead an anti-aircraft gun, bullet is fired from the gun, at an angle θ with the horizontal, to hit the jet. If the bullet speed is 400 m/s, the value of θ will be ———^{0}

JEE Main-26.06.2022, Shift-I

Ans. (60°) : Given that,

Speed of the fighter jet, $v_1 = 200$ m/s

The speed of the bullet, $v_2 = 400$ m/s

We know that, when both the bodies are in the same horizontal component of the velocity then they are written as; $v_1 = v_2 \cos\theta$

Now, on putting the value of v_1 and v_2 we have;

$$200 = 400\cos\theta$$

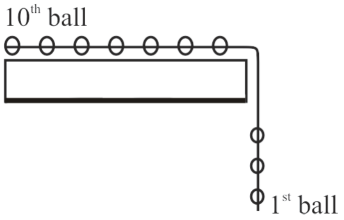
$$\cos\theta = \frac{200}{400}$$

$$\cos\theta = \frac{1}{2}$$

$$\cos\theta = \cos 60°$$

$$\theta = 60°$$

223. A system to 10 balls each of mass 2 kg are connected via mass less and stretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is ——— N when 6th ball just leaves the table.



JEE Main-26.06.2022, Shift-II

Ans. (36) : At given instant –

$$\text{Acceleration, } a_{system} = \frac{6mg}{10m} = \frac{6g}{10} = \frac{3g}{5}$$

Taking 8,9,10 together

$$\therefore\ T = 3ma_{system}$$

$$= 3m \times \frac{3g}{5}$$

$$= 3 \times 2 \times \frac{3\times 10}{5} \qquad (\because\ g = 10\ \text{m/sec}^2)$$

$$= 36\ \text{N}$$

224. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1}. The impulse imparted to the ball is ——— Ns

JEE Main-26.06.2022, Shift-II

Ans. (12) : Given data,

Mass, (m) = 0.4 kg

Initial speed, (u) = 15 ms^{-1}

Impulse, [J] = ?

We know that,

$$J = \Delta p$$

$$J = p_f - p_i$$

$$J = mv - (-mv)$$

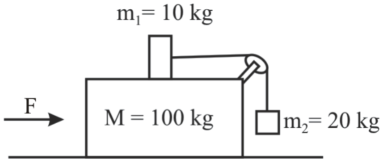
$$J = 2\ mv$$

$$J = 2 \times 0.4 \times 15$$

$$J = 12\ \text{N-s}$$

225. Three masses M = 100 kg, m_1 = 10 kg, and m_2 = 20 kg are arranged in a system as shown in figure. All the surfaces are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of 2ms^{-2}. The value of F is :

(Take g = 10 ms^{-2})

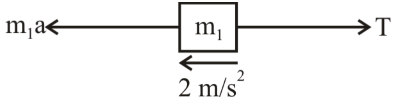


(a) 3360 N
(b) 3380 N
(c) 3120 N
(d) 3240 N

JEE Main-26.07.2022, Shift-I

Ans. (c) : In frame of block of mass M moving with acceleration a.

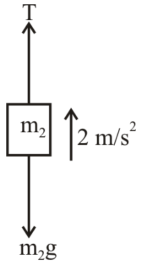
FBD of 10 kg block w.r.t. 100 kg



$$m_1a - T = 2m_1$$

$$10a - T = 20 \qquad \ldots(i)$$

Now, FBD of 20 kg block w.r.t. 100 kg-



$$T - m_2g = m_2.2$$

$$T - 20 \times 10 = 20 \times 2$$

$$T - 200 = 40$$

$$T = 240 \qquad \ldots(ii)$$

From equation (i) and (ii)

$$10a - 240 = 20$$

$$10a = 260$$

$$a = 26\ \text{m/s}^2$$

For block m_2-

$$F = (M + m_2)a = 120 \times 26$$

$$F = 3120\ \text{N}$$

226. A shell of mass m is at rest initially. It explodes into three fragments having mass in the ratio 2:2:1. If the fragments having equal mass fly off along mutually perpendicular directions with speed v, the speed of the third (lighter) fragment is

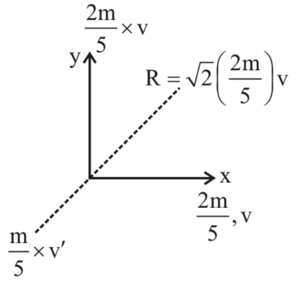
@apna_pdf

(a) $2\sqrt{2}\,v$ (b) $3\sqrt{2}\,v$

(c) v (d) $\sqrt{2}\,v$

NEET-2022

Ans. (a) : Given,
Ratio of mass = 2:2:1



Here we calculate the resultant force of x and y-axis then we get,

$$R=\sqrt{F_x^2+F_y^2}$$

Now we apply the law conservation of momentum–

$$\frac{m}{5}\times v'=\sqrt{2}\times\frac{2m}{5}v$$

$$v'=2\sqrt{2}\,v$$

227. A moving particle collides with a stationary particle of mass $\frac{1}{n}$ times the mass of moving particle, the fraction of its kinetic energy transferred to the stationary particle is

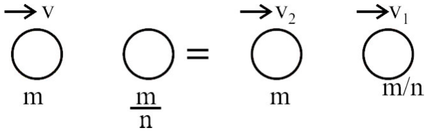
(a) $\frac{4n^2}{(1+n)^2}$ (b) $\frac{4n}{(1+n)^2}$

(c) $\frac{4n}{1+n^2}$ (d) $4n^2$

TS EAMCET 18.07.2022, Shift-II

Ans. (b) : Let, the mass of moving particle = m

Then the mass of stationary particle = $\frac{m}{n}$



From law of energy conservation

Potential energy in Initial = Potential energy in final state

$$P_i=P_f$$

$$mv=mv_2+\frac{mv_1}{n}$$

$$v=v_2+\frac{v_1}{n} \qquad \text{…(i)}$$

$$\therefore \quad e=\frac{\text{velocity of seperation}}{\text{velocity of approach}}$$

$$1=\frac{v_1-v_2}{v} \qquad [\because \text{perfectly velocity}]$$

$$v=v_1-v_2 \qquad \text{… (ii)}$$

Adding equation (i) to (ii)

$$2v=v_1+\frac{v_1}{n}$$

$$2v=v_1+\frac{(v+1)}{n}\Rightarrow v_1=\frac{2n}{(n+1)}v$$

Initial K.E. of $(K_i)_{\text{at } m}=\frac{1}{2}mv^2$

Final K.E. of $(K_f)_{\text{at } \frac{m}{n}}=\frac{1}{2}\frac{m}{n}\times v_1^2$

$$=\frac{1}{2}\times\frac{m}{n}\left(\frac{2n}{n+1}v\right)^2$$

$$=\frac{1}{2}\times\frac{m}{n}\times\frac{4n^2}{(1+n)^2}.v^2$$

$$=\frac{1}{2}m\frac{4n}{(1+n)^2}.v^2$$

Now, $$\frac{K_i}{K_f}=\frac{\frac{1}{2}mv^2}{\frac{1}{2}m\frac{4n}{(1+n)^2}.v^2}$$

$$\frac{K_i}{K_f}=\frac{1}{\frac{4n}{(1+n)^2}}$$

$$K_f=\frac{4n}{(1+n)^2}.K_i$$

228. If the momentum of a body is doubled, the kinetic energy becomes

(a) doubled (b) halved

(c) four times (d) three times

TS EAMCET 30.07.2022, Shift-I

Ans. (c) : Let,
mass of body, m
velocity, v

kinetic energy, (KE) = $\frac{1}{2}mv^2$

$$=\frac{1}{2}\frac{m^2v^2}{m}$$

$$(KE)=\frac{1}{2}\frac{p^2}{m} \qquad \text{…(i)} \qquad [\because \text{momentum}, p=mv]$$

According to question,

$$p_1=2p$$

Now,

$$(KE)_1=\frac{1}{2}\times\frac{p_1^2}{m}$$

$$=\frac{1}{2}\times\frac{4p^2}{m}=\frac{1}{2}\times\frac{p^2}{m}\times 4$$

$$(KE)_1=(4KE)$$

Hence, momentum of a body is doubled, the kinetic energy becomes four times.

@apna_pdf

229. An iron ball of 4kg moving with a speed of 6 m/s makes head-on collision with another iron ball of 6kg moving with the speed of 2m/s along the same line. After collision, if both the balls move together with the same speed, the common speed of both balls. is

(a) 3.6 m/s (b) 2 m/s
(c) 1.2 m/s (d) 3 m/s

TS EAMCET 31.07.2022, Shift-II

Ans. (c) : Given,
$m_A = 4$ kg, $v_A = 6$ m/s, $m_B = 6$kg, $v_B = -2$m/s, $V_0 = ?$
The two bodies move together with common velocity after the impact.
According to conservation of momentum,
$m_Av_A + m_Bv_B = (m_A + m_B)V_0$
$4 \times 6 + 6 \times (-2) = (4 + 6)V_0$
$24 - 12 = (10)V_0$
$V_0 = \dfrac{12}{10} = 1.2$ m/s

230. A body of mass 2 kg moves with an acceleration 3 ms^{-2}. The change in momentum in one second is:

(a) $\frac{2}{3}\text{kg m s}^{-1}$ (b) $\frac{3}{2}\text{kg m s}^{-1}$
(c) 6kg m s^{-1} (d) 5 kg m s^{-1}

AP EAMCET-06.09.2021, Shift-I

Ans. (c) : Given that,
Mass of the body (m) = 2 kg
Acceleration of the body (a) = 3m/sec^2
By Newton's second law
Rate of change of momentum is equal to applied force

$$F = \frac{dp}{dt}$$
$$\int_0^1 F dt = \int_{P_1}^{P_2} dp$$
$$F\int_0^1 dt = \int_{P_1}^{P_2} dp$$
$$F[t]_0^1 = [p]_{P_1}^{P_2}$$
$$F(1-0) = p_2 - p_1$$
$$F = \Delta p \qquad \text{.... (i)}$$
$\because$ $F = ma$
$F = 2 \times 3$
$F = 6$ N
$\therefore$ $\Delta p = 6$ kg m s^{-1} {from (i)}
So, change of momentum in one second is 6 kg ms^{-1}

231. Identify the incorrect statement from the following

(a) Energy, mass and force are conserved.
(b) Yukawa gave the theory of nuclear forces.
(c) Strong nuclear forces have the shortest range of order of 10^{-15}m.
(d) Both gravitational and electromagnetic forces obey inverse square law.

AP EAMCET (Medical)-05.10.2021, Shift-I

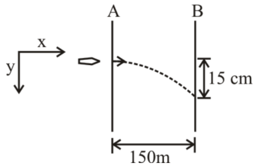
Ans. (a) :
(i) Energy and mass is conserved in any system. But force need not to be conserved.
(ii) According to Yukawa's theory of nuclear forces, the origin of nuclear force between nucleons is due to the exchange of mesons.
The lightest member of a large family of particle is called mesons.
(iii)Nuclear forces are the forces responsible for binding protons and neutrons ("nucleons") together into atomic nuclei. These forces act only for a few ferometer 1fm= 10^{-15}, beyond which it decreases rapidly hence its effect is merely felt. It is one of the basic fundamental forces in nature.
(iv) Both gravitational and electromagnetic forces obey inverse square law.

232. Two paper screens A and B are separated by 150 m. A bullet pierces A and then B. The hole in B is 15 cm below the hole in A. If the bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is: (g= 10 ms^{-2})

(a) $100\sqrt{3}$ m.s^{-1} (b) $200\sqrt{3}$ m.s^{-1}
(c) $300\sqrt{3}$ m.s^{-1} (d) $500\sqrt{3}$ m.s^{-1}

AP EAMCET-20.08.2021, Shift-II

Ans. (d) :



We know that,
$s = ut + \frac{1}{2}at^2$
Applying along y-direction,
$15 \times 10^{-2} = \frac{1}{2}(10)t^2 \qquad (\because u_y = 0)$
$t^2 = \frac{30}{1000} = \frac{3}{100}$
$t = \frac{\sqrt{3}}{10}$ sec.
Now, along x-direction,
Distance = velocity × time
$150 = u_x \times \frac{\sqrt{3}}{10}$
$u_x = 500\sqrt{3}$ m/s

233. If bullet of mass 'm$_1$' is fired from a gun of mass 'm$_2$' with a speed of 'V$_1$', then the recoil velocity of gun is

(a) $-\dfrac{m_1V_1}{m_2}$ (b) $-\dfrac{m_2}{m_1V_1}$
(c) $-\dfrac{m_2}{m_1V_1}$ (d) $\dfrac{m_1V_1}{m_2}$

AP EAMCET-24.08.2021, Shift-II
MHT-CET 2019

@apna_pdf

Ans. (a) : Mass of bullet = m_1

Mass of gun = m_2

Speed of gun = V_1

Recoil velocity of gun = ?

According to the law of conservation of momentum,

$$0 = m_1.V_1 + m_2V_2$$

$$-m_1.V_1 = m_2.V_2$$

$$V_2 = \frac{-m_1V_1}{m_2}$$

234. A bomb at rest explodes into three parts of equal mass. If the momentum of two parts are $-2p\hat{i}$ and $p\hat{j}$, find the magnitude of momentum of third part.

(a) p (b) $\sqrt{3}p$

(c) $\sqrt{5}p$ (d) 0

AP EAMCET (18.09.2020) Shift-II

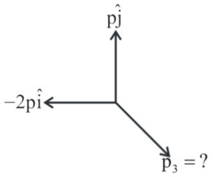
Ans. (c) : Given that,

Momentum of first part = $-2p\hat{i}$

Momentum of second part = $p\hat{j}$

p_1, p_2 and p_3 are momentum of first, second and third part.

Magnitude of linear momentum of third particle-



$$p_3 = \sqrt{p^2 + (-2p)^2}$$

$$p_3 = \sqrt{p^2 + 4p^2}$$

$$p_3 = \sqrt{5p^2}$$

$$p_3 = \sqrt{5}p$$

235. A 12 kg bomb, when exploded, gets divided in two parts whose masses are in the ratio 1:3. If the kinetic energy of smaller part is 216 J, the momentum of bigger part is ____ kg. m.s^{-1}

(a) 36 (b) 72

(c) 108 (d) Data insufficient

AP EAMCET-25.09.2020, Shift-II

Ans. (a) : Ratio of masses after division = 1 : 3

So, $m_1 = \frac{1}{4}\times 12 = 3$ kg

$m_2 = \frac{3}{4}\times 12 = 9$ kg

Since momentum is conserved,

Therefore,

Initial momentum of the system is zero and the final momentum of the system will also be zero.

Then, $P_{initial} = P_{final}$

We know that,

Kinetic energy (KE) = $\frac{P^2}{2m}$

Where,

P = momentum of the body

m = mass of the body

Kinetic energy of bigger part (K_b) $= \frac{P_b^2}{2m_b}$

Kinetic energy of smaller part (K_s) $= \frac{P_s^2}{2m_s}$

According to conservation of momentum,

$$P_b = P_s$$

Therefore, $P_b^2 = P_s^2$

$$P_b^2 = K_s(2m_s) \qquad [\because P_b^2 = P_s^2]$$

$$P_b^2 = 216 \times (2 \times 3)$$

$$P_b = 36 \text{ kg m/s}$$

236. A free body of mass 8 kg is moving at 2m.s^{-1} along a straight line. It splits into two equal parts due to an internal explosion releasing 16 J of energy, and neither part deviates from the original line of motion. Finally,

(a) Both parts continue to move in the same direction as that of the original body

(b) One part comes to rest and the other moves in the same direction as that of the original body

(c) One part comes to rest and the other moves in the direction opposite to that of the original body

(d) One part moves in the same direction and the other in the direction opposite to that of the original body

AP EAMCET-07.10.2020, Shift-I

Ans. (b) : When the body splits into two equal parts, momentum of the system will remain conserved –

$$mv = m_1v_1 + m_2v_2$$

$$8 \times 2 = 4v_1 + 4v_2$$

$$v_1 + v_2 = 4 \qquad \ldots(i)$$

From the law of conservation of energy–

Initial kinetic energy + energy released due to explosion = final kinetic energy of the system

$$\frac{1}{2}\times 8 \times (2)^2 + 16 = \frac{1}{2}\times 4v_1^2 + \frac{1}{2}\times 4v_2^2$$

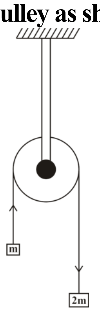
$$v_1^2 + v_2^2 = 16 \qquad \ldots(ii)$$

By solving the equation (i) and (ii), we get

$v_1 = 4$ and $v_2 = 0$

It means one part moves in the same direction that of the original body and other part come to rest.

237. Two masses m and 2m are hang from a frictionless. Weightless ideal pulley as shown below:



@apna_pdf

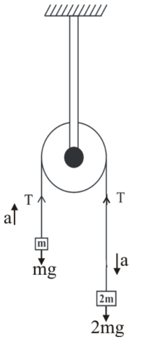
The upward acceleration of the mass m is

(a) $\frac{g}{8}$ (b) $\frac{g}{4}$

(c) $\frac{g}{3}$ (d) $\frac{g}{2}$

Tripura-2020

Ans. (c) :



$2mg - T = 2ma$ ...(i)

And $T - mg = ma$ ...(ii)

By adding equation (i) and (ii)

$2mg - mg = 3\,ma$

$mg = 3ma$

$a = \frac{g}{3}$

238. A bomb at rest explodes into three parts of the same mass. The linear moment of the two parts are $-2p\hat{i}$ and $p\hat{j}$. The magnitude of momentum of the third part is

(a) $5\sqrt{p}$ (b) $p^2\sqrt{3}$

(c) $p\sqrt{5}$ (d) $25\sqrt{p}$

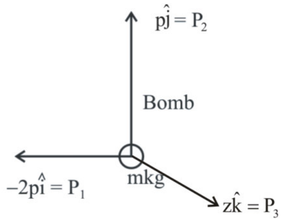
Assam CEE-2020

Ans. (c): Given that,

Momentum of first part $P_1 = -2\,p\hat{i}$

Momentum of second part $p_2 = p\hat{j}$

$m_1 = m_2 = m_3 = m$



Now apply conservation of linear momentum,

$\vec{P}_{initial} = \vec{P}_{final}$

$P_1 + P_2 + P_3 = 0$

$-2p\hat{i} + p\hat{j} + p_3 = 0$

$P_3 = (2p\hat{i} - p\hat{j})$

$\therefore |P_3| = \sqrt{(2p)^2 + (-p)^2}$

$= \sqrt{4p^2 + p^2}$

$= (\sqrt{5})p$

239. Two balls A and B of masses 50 kg and 20 kg are moving in a straight line in the same direction at speed of 9 km/h and 18 km/h respectively. Ball B hits A and reverses its direction at a speed of 27 km/h. The speed of the ball A after the collision is

(a) 27 km/h (b) 18 km/h

(c) 22.5 km/h (d) 15 km/h

TS EAMCET 28.09.2020, Shift-I

Ans. (a) : Given that,

mass of A = 50kg

mass of B = 20kg

initial velocity of A (u_A) = 9 km/h

initial velocity of B (u_B) = 18 km/h

final velocity of B (v_B) = –27 km/h

Let the velocity of the ball A after the collision (v_A) = x

According to the law of conservation of momentum,

$m_A u_A + m_B u_B = m_A v_A + m_B v_B$

$50 \times 9 + 20 \times 18 = 50 \times x + 20 \times (-27)$

$450 + 360 = 50x - 20 \times 27$

$810 = 50x - 540$

$1350 = 50x$

$x = 27$km/h

240. A shell of mass 'M' initially at rest suddenly explodes in three fragments. Two of these fragments are of mass 'M/4' each, which move with velocities 3 ms^{-1} and 4 ms^{-1} respectively in mutually perpendicular directions. The magnitude of velocity of the third fragment is

(a) 2.5 ms^{-1} (b) 1.5 ms^{-1}

(c) 3.0 ms^{-1} (d) 2.0 ms^{-1}

MHT-CET 2020

Ans. (a) : At the rest, initial momentum of body mass 'm' = 0

From the law of conservation of momentum,

The net momentum of the three pieces should be zero.

The moments of the two pieces

$P_1 = \frac{3M}{4}$ and $P_2 = \frac{4M}{4}$

Then, their resultant will be $P = \sqrt{P_1^2 + P_2^2}$

$= \sqrt{\left(\frac{3M}{4}\right)^2 + \left(\frac{4M}{4}\right)^2}$

$= \frac{M}{4}\sqrt{(3)^2 + (4)^2}$

$= \frac{M}{4}\sqrt{25} = \frac{5M}{4}$

Since, the mass of the third piece will be $\frac{M}{2}$

If its velocity = v

Then,

$\frac{M}{2}.v = \frac{5M}{4}$

$\therefore \quad v = 2.5$ ms^{-1}

@apna_pdf

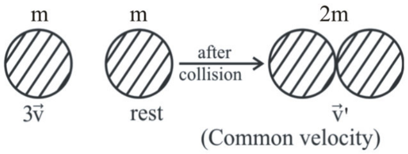
241. A block of mass 'm' moving along a straight line with constant velocity $3\vec{v}$ collides with another block of same mass at rest. They stick together and move with common velocity. The common velocity is

(a) $\frac{3\vec{v}}{2}$ (b) $3\vec{v}$

(c) $\vec{v}$ (d) $2\vec{v}$

MHT-CET 2020

Ans. (a) :



Apply conservation of momentum–

$$m\vec{v}_1 + m\vec{v}_2 = (m+m).\vec{v}'$$
$$m.3\vec{v} + m.0 = (2m).\vec{v}'$$
$$3m.\vec{v} = 2m.\vec{v}'$$
$$\vec{v}' = \frac{3m.\vec{v}}{2m} = \frac{3\vec{v}}{2}$$

Common velocity,

$$\vec{v}' = \frac{3}{2}\vec{v}$$

242. A stationary body explodes into two parts of masses 'M_1' and 'M_2'. They move in opposite directions with velocities 'v_1' and 'v_2'. The ratio of their kinetic energies is

(a) $\left[\frac{M_2}{M_1}\right]$ (b) $\left[\frac{M_2}{M_1}\right]^{\frac{1}{2}}$

(c) $\left[\frac{M_2}{M_1}\right]^2$ (d) $\left[\frac{M_1}{M_2}\right]^2$

MHT-CET 2020

Ans. (a) : From the law of conservation of linear momentum.

$$M_1v_1 - M_2v_2 = 0$$
$$\therefore \quad \frac{M_1}{M_2} = \frac{v_2}{v_1}$$
$$\frac{E_1}{E_2} = \frac{\frac{1}{2}M_1v_1^2}{\frac{1}{2}M_2v_2^2} = \frac{M_1}{M_2}\left(\frac{v_1}{v_2}\right)^2 = \frac{M_1}{M_2}\left(\frac{M_2}{M_1}\right)^2$$
$$\boxed{\frac{E_1}{E_2} = \frac{M_2}{M_1}}$$

243. A body of mass 'M' moving with velocity 'V' explodes into two equal parts. If one part comes to rest and the other part moves with velocity 'v_0'. What would be the value of 'v_0' ?

(a) V (b) 2V

(c) $\frac{V}{\sqrt{2}}$ (d) 4V

MHT-CET 2020

Ans. (b) : Before explosion–

The total momentum of the system = MV

After explosion,

Total momentum of the system–

$$= \frac{M}{2} \times 0 + \frac{M}{2}v_0 = \frac{Mv_0}{2}$$

By the law of conservation of momentum,

$$MV = \frac{Mv_0}{2}$$
$$2MV = Mv_0$$
$$v_0 = 2V$$

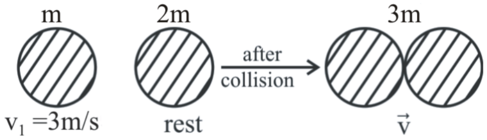
244. A body of mass 'm' moving with speed 3 m/s collides with a body of mass '2m' at rest. The coalesced mass will start to move with a speed of

(a) 3 m/s (b) 1 m/s

(c) 6 m/s (d) 9 m/s

MHT-CET 2020

Ans. (b) : According to question-



By applying law of conservation of momentum

$$P_i = P_f$$
$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2).\vec{v}$$
$$3m + 0 = (3m).\vec{v}$$
$$\vec{v} = \frac{3m}{3m} = 1m/sec.$$

Hence coalesced mass start to move with 1 m/sec.

245. A bullet of mass m moving with velocity 'v' is fired into a wooden block of mass 'M'. If the bullet remains embedded in the block, the final velocity of the system is

(a) $\frac{mv}{m+M}$ (b) $\frac{m+M}{m}$

(c) $\frac{M+m}{mv}$ (d) $\frac{v}{m(M+m)}$

MHT-CET 2020

Ans. (a) : From question,

Let v_1 is the final velocity of the bullet-block system.

From law of conservation of momentum,

Initial momentum = final momentum

$$mv + m(0) = (m + M)\ v_1$$
$$v_1 = \frac{mv}{m+M}$$

246. A bomb at rest explodes in to three parts of same mass. The momentum of two parts is $(-)3P\hat{i}$ and $2P\hat{j}$ respectively. The magnitude of the momentum of third part is

(a) $\sqrt{13}P$ (b) $\sqrt{15}P$

(c) $\sqrt{11}P$ (d) $\sqrt{7}P$

MHT-CET 2020, 2018

@apna_pdf

Ans. (a) : Question says that bomb explodes into three parts of same mass,

So all particles should have mass;

$$m_1 = m_2 = m_3 = \frac{m}{3}$$

Now,

$$\text{Initial momentum of bomb } \left(\vec{P}_{\text{initial}}\right) = 0$$

Momentum of first particle $\vec{P}_1 = -3P\hat{i}$

Momentum of 2nd particle $\vec{P}_2 = 2P\hat{j}$

Momentum of third particle = $\vec{P}_3$

from conservation of momentum,

$$\vec{P}_{\text{initial}} = \vec{P}_{\text{final}}$$

So,

$$\vec{P}_{\text{initial}} = \vec{P}_1 + \vec{P}_2 + \vec{P}_3$$

As we know, here initial momentum = 0

$$\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0$$

Putting the values,

$$-3P\hat{i} + 2P\hat{j} + \vec{P}_3 = 0$$

$$\vec{P}_3 = 3P\hat{i} - 2P\hat{j}$$

Now magnitude,

$$\vec{P}_3 = \sqrt{(3P)^2 + (-2P)^2}$$

$$\vec{P} = \sqrt{13P^2}$$

$$\vec{P} = \sqrt{13}\,P$$

247. When a bullet is fired from a rifle its momentum becomes 20 kg-ms^{-1}. If the velocity of the bullet is 1000 ms^{-1}, then what is its mass?

(a) 30 g (b) 5 kg

(c) 20 g (d) 500 g

TS-EAMCET-10.09.2020, Shift-1

Ans. (c) : Given,

Momentum of bullet after firing (p) = 20 kg m/s

Velocity of the bullet (v) = 1000 ms^{-1}

We know that,

$$p = mv$$

$$m = \frac{p}{v} = \frac{20}{1000}\text{kg}$$

$$m = 20\text{g}$$

248. A ball of mass M moving with a speed of 2 m/s hits another ball of mass 1 kg moving in the same direction with a speed of 1 m/s. If the kinetic energy of centre of mass is $\frac{4}{3}$ J, then the magnitude of M is

(a) 1 kg (b) 0.25 kg

(c) 0.50 kg (d) 2 kg

TS-EAMCET-09.09.2020, Shift-1

Ans. (c) : Given,

Mass of first ball (m_1) = M

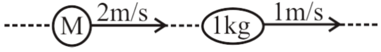
Velocity of first ball (v_1) = 2m/s

Mass of second ball (m_2) = 1 kg

Velocity of second ball (v_2) = 1 m/s

Kinetic energy (K) = $\frac{4}{3}$ J

According to question,



According to given condition, kinetic energy of centre of mass remains same before and after collision.

Now,

$$v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

$$v_{cm} = \frac{2M+1}{M+1} \qquad \text{....(i)}$$

$$\therefore \quad \text{K.E} = \frac{1}{2}mv^2$$

$$\frac{4}{3} = \frac{1}{2}(M+1).v_{cm}^2$$

$$\frac{8}{3} = (M+1)\left(v_{cm}^2\right) \qquad \text{[From equation (i)]}$$

$$\frac{8}{3} = (M+1)\left(\frac{2M+1}{M+1}\right)^2$$

$$\frac{8}{3} = \frac{(2M+1)^2}{M+1}$$

$$3(2M+1)^2 = 8M + 8$$

$$12M^2 + 12M - 8M + 3 - 8 = 0$$

$$12M^2 + 4M - 5 = 0$$

$$12M^2 + 10M - 6M - 5 = 0$$

$$(2M - 1)(6M + 5) = 0$$

$$M = \frac{1}{2} \text{ or } M = \frac{-5}{6}$$

So, mass (M) = $\frac{1}{2}$ = 0.5kg

249. A bomb of mass 9kg explodes into two pieces of mass 3kg and 6kg. The velocity of mass 3kg is 16m/s. The kinetic energy of mass 6kg (in joule) is

(a) 96 (b) 384

(c) 192 (d) 768

AP EAMCET (21.09.2020) Shift-II

J&K CET- 2007

Ans. (c) : M = 9kg, m_1 = 3kg, v_1 =16 m/s, m_2 = 6kg

Law of conservation of momentum,

$$p_i = p_f$$

$$m_1v_1 = m_2v_2$$

$$v_2 = \frac{m_1v_1}{m_2}$$

$$\because \text{K.E.} = \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_2\left(\frac{m_1v_1}{m_2}\right)^2 = \frac{1}{2}\frac{m_1^2v_1^2}{m_2}$$

$$= \frac{(3)^2 \times (16)^2}{2\times 6} = 192\,\text{J}$$

@apna_pdf

250. The time taken by a force of 2N to produce a change of momentum of 0.4 kg ms^{-1} in a body is

(a) 0.2 s (b) 0.02 s

(c) 0.5 s (d) 0.05 s

AP EAMCET (23.09.2020) Shift-I

Ans. (a) : Given that, force (F) = 2N, change in momentum (ΔP) = 0.4 kg ms^{-1}

$$\text{Force (F)} = \frac{\text{Change in momentum }(\Delta P)}{\text{Time taken }(\Delta t)}$$

or $$\Delta t = \frac{\Delta P}{F} = \frac{0.4}{2} = 0.2\,\text{s}$$

251. A bullet of mass 10 g is fired from a gun of mass 1 kg. If the recoil velocity is 5 m/s, the velocity of the muzzle is

(a) 0.05 m/s (b) 5 m/s

(c) 50 m/s (d) 500 m/s

Manipal UGET-2019

Ans. (d) : Given,

Mass of bullet (m_b) = 10 g = $\left(\frac{10}{1000}\right)$kg

Mass of gun (m_g) = 1 kg

Recoil velocity (v_r) = – 5 m/s

Muzzle velocity (v_m) = ?

Conservation of linear momentum gives,

$$m_g v_r + m_b v_m = 0$$

$$v_m = -\frac{m_g v_r}{m_b}$$

$$v_m = -\frac{1\times(-5)}{\frac{10}{1000}} = \frac{5}{10}\times 1000$$

$$v_m = 500\ \text{m/sec}$$

252. A soccer ball is travelling at a velocity 20 ms^{-1} due south. At the end of its travel, it moves with a velocity 2 ms^{-1} due south. If the change in the linear momentum of the ball is 18 kgms^{-1} due north, then the mass of the ball is

(a) 3.0 kg (b) 0.81 kg

(c) 1.0 kg (d) 0.5 kg

AP EAMCET-23.04.2019, Shift-II

Ans. (c) : Given,

$$\vec{v}_1 = (-20\hat{j})\ \text{m/s}$$

$$\vec{v}_2 = (-2\hat{j})\ \text{m/s}$$

$$\text{and } \Delta\vec{p} = (18\hat{j})\,\text{kg m/s}$$

We know that,

$$p = mv$$

$$\Delta\vec{p} = p_f - p_i$$

$$\Delta\vec{p} = mv_2 - mv_1$$

$$18\hat{j} = m[-2\hat{j} - (-20\hat{j})]$$

$$18\hat{j} = m(18\hat{j})$$

$$m = 1\text{kg}$$

253. A bomb is kept stationary at a point. It suddenly explodes into two fragments of masses 1 kg and 3 kg. The total kinetic energy of the fragments is 6.4 × 10^7 J. The kinetic energy of the smaller fragment is

(a) 2.5 × 10^7 J (b) 3.5 × 10^7 J

(c) 4.8 × 10^7 J (d) 5.2 × 10^7 J

TS EAMCET 09.05.2019, Shift-I

Ans. (c): As the momentum of both fragments are equal.

Therefore,

$$\frac{E_1}{E_2} = \frac{M_2}{M_1} \Rightarrow E_1 = 3E_2 \qquad \text{....(i)}$$

According to question,

$$E_1 + E_2 = 6.4 \times 10^7\ \text{Joule} \qquad \text{....(ii)}$$

From equation (i) and (ii),

$$3E_2 + E_2 = 6.4 \times 10^7\ \text{J}$$

$$4E_2 = 6.4 \times 10^7\ \text{J}$$

$$E_2 = 1.6 \times 10^7\ \text{J}$$

Then, $E_1 = 3E_2 = 3 \times 1.6 \times 10^7$

$= 4.8 \times 10^7$ Joule

254. Assertion (A): When a body at rest breaks into two pieces of equal mass. The two pieces move in opposite direction with same speed.

Reason (R): Conservation of momentum.

The correct answer is

(a) (A) is true but the (R) is false

(b) Both (A) and (R) are false

(c) Both (A) and (R) are true and (R) is the correct explanation of (A).

(d) Both (A) and (R) are true but (R) is not correct explanation of (A).

TS EAMCET 09.05.2019, Shift-I

Ans. (c) : Law of conservation of momentum states that for two or more bodies in an isolated system acting upon other, their total momentum remains constant unless on external force is applied. Therefore, momentum can neither be created nor destroyed.

Hence, Assertion (A) and Reason (R) is correct and (R) is the correct explanation of (A)

255. A particle having a mass 0.5 kg is projected under gravity with a speed of 98 m/sec at an angle of 60°. The magnitude of the change in momentum (in N-sec) of the particle after 10 seconds is [g = 9.8m/sec^2]

(a) 0.5 (b) 49

(c) 98 (d) 490

VITEEE-2019

Ans. (b) : Given,

Mass of particle (m) = 0.5 kg

Particle is projected with a speed = 98 m/s

$$\Delta p = ?$$

Let the horizontal component be u_x and the vertical component be u_y.

Let the particle's initial vertical momentum be p_y and its vertical velocity and momentum after 10s be v_y and p'_y.

@apna_pdf

Therefore, the change in momentum of the particle is–

$$\Delta P = p'_y - p_y = mv_y - mu_y$$

$$\Delta P = m(v_y - u_y) \quad \ldots\ldots \text{(i)}$$

Here $v = v_y$, $u = u_y$, $a = -g$ and $t = 10$ s

From first equation of motion,

$$v = u + at$$

$$v_y = u_y - g \times 10$$

$$v_y - u_y = (-g)(10)$$

$$v_y - u_y = (-9.8)(10) = -98 \text{ m/s}$$

Substitute the values of m and $(v_y - u_y)$ in equation (i),

$$\Delta p = 0.5(-98) = -49 \text{ m/s}$$

So,

Magnitude of change of momentum of the particle = 49 kg m/s

256. Assertion: A glass ball is dropped on concrete floor can easily get broken compared if it is dropped on wooden floor.

Reason: On concrete floor glass ball will take less time to come to rest.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-25.05.2019(M) Shift-1

Ans. (a) : If a glass ball is dropped on the concrete floor then' it will take less time to come in rest because concrete floor exerted more force than wood.

Hence, if both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

257. A gun of mass 10 kg fires 4 bullets per second. The mass of each bullet is 20 g and the velocity of the bullet when it leaves the gun is 300 ms^{-1}. The force required to hold the gun while firing is

(a) 6 N (b) 8 N

(c) 24 N (d) 240 N

AIIMS-25.05.2019(E) Shift-2

Ans. (c) : Given,

Mass of gun = 10 kg

No. of bullets firing per second = 4

Mass of each bullet = 20 g = 0.02 kg

Velocity of bullet = 300 ms^{-1}

We know that,

Force (F) = rate of change of momentum (ΔP)

$$F = n.\frac{mv}{\Delta t}$$

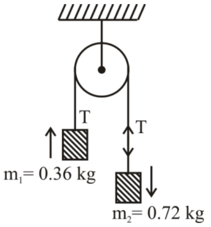
$$F = 4 \times \frac{mv}{\Delta t}$$

$$F = \frac{4 \times 0.02 \times 300}{1}$$

$$F = 24 \text{ N}$$

258. In the arrangement shown in the figure, work done by the string on the block of mass 0.36 kg during the first second after the blocks are released from state of rest is (Ignore friction and mass of the string.)

(Acceleration due to gravity, g = 10 ms^{-2})

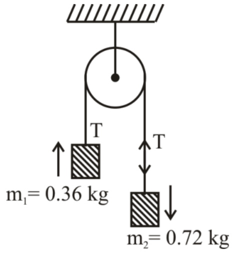


(a) 8 J (b) 4 J

(c) 12 J (d) 2 J

AP EAMCET (22.04.2019) Shift-I

Ans. (a) : According to the question,



Given, mass of block 1 $(m_1) = 0.36$ kg

mass of block 2 $(m_2) = 0.72$ kg

and acceleration due to gravity (g) = 10 m/s^2

Now, Dynamic equation of block m_1 $(m_2 > m_1)$.

$$\therefore \quad T - m_1 g = m_1 a \quad \ldots\text{(i)}$$

Dynamic equation of block m_2 $(m_2 > m_1)$.

$$\therefore \quad m_2 g - T = m_2 a \quad \ldots\text{(ii)}$$

Thus from adding equation (i) and (ii), we get–

$$a = \frac{(m_2 - m_1)g}{(m_1 + m_2)}$$

$$\therefore \quad a = \frac{(0.72 - 0.36)}{1.08} \times 10$$

$$a = \frac{3.6}{1.08} \text{ m/s}^2 \quad \ldots\text{(iii)}$$

Now, the tension force in the string is,

for block 1st, $m_1 = 0.36$ kg

$$T - m_1 g = m_1 a$$

$$\frac{T - m_1 g}{m_1} = a$$

$$\frac{T - 3.6}{0.36} = \frac{3.6}{1.08}$$

$$T = 3.6 + 0.36 \times \frac{3.6}{1.08}$$

$$T = 4.8\text{N}$$

...(iv)

Distance travelled by block 1,

By displacement – time relation,

@apna_pdf

Displacement, $s = ut + \frac{1}{2}at^2$ $[\because u = 0]$

[by kinetic equation for uniformly motion]

$$s = \frac{1}{2} \times \frac{3.6}{1.08} \times (1)^2 \quad [\therefore\ t = 1 \text{ second given }]$$

$$s = \frac{1}{2} \times \frac{3.6}{1.08} = 1.6 \qquad \text{...(v)}$$

Now, work done by the string on the block of mass (m_1) is 0.36 kg.

$\therefore$ Work done (W) = Tension force (T)×displacement (s)

$$W = T \times s$$

From equation (iv) and (v), we get–

$$W = 4.8 \times 1.6 = 7.68\text{ J} \approx 8\text{ J}$$

259. An explosion blows a stationary rock into three parts. Two parts of masses 1kg and 2 kg moves at right angles to one another with velocities 12ms^{-1} and 8ms^{-1}, respectively. If the velocity of third part is 4 ms^{-1}, the mass of the rock is

(a) 8 kg (b) 5 kg

(c) 17 kg (d) 3 kg

AP EAMCET (23.04.2019) Shift-I
NEET- 2013
Kerala CEE - 2011

Ans. (a) : Given that,

$m_1 = 1\text{kg}, m_2 = 2\text{kg}, v_1 = 12 \text{ ms}^{-1}$

$v_2 = 8\text{ms}^{-1}, v_3 = 4 \text{ ms}^{-1}$

$P_1 = m_1v_1 = 1 \times 12 = 12$ N-s

$P_2 = m_2v_2 = 2 \times 8 = 16$ N-s

$\therefore \quad \vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0$

$|\vec{P}_3| = |\vec{P}_1 + \vec{P}_2|$

$m_3 \times 4 = \sqrt{P_1^2 + P_2^2} = \sqrt{12^2 + 16^2} = 20$

$m_3 = 5$ kg

Hence, the mass of the rock is

$m = m_1 + m_2 + m_3$

$m = 1 + 2 + 5 = 8$ kg

260. The only force acting on a 2 kg body that is moving in xy plane has a magnitude of 5 N. The body initially has a velocity of 4 ms^{-1} in the positive x direction. Sometime later the body has a velocity of 6 ms^{-1} in the positive y direction. The work done on the body by the 5 N force during this time is

(a) 20 J (b) 40 J

(c) 52 J (d) 72 J

AMU-2018

Ans. (a) : Given, $m = 2$ kg, $v_1 = 4$m/s , $v_2 = 6$m/s, $F = 5$N

According to work-energy theorem,

$$\int F_{net}dx = \Delta KE = (KE)_2 - (KE)_1$$

$$= \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = \frac{1}{2}\left[2\times(6)^2 - 2\times(4)^2\right]$$

$$= \frac{2}{2}[36-16] = 20\text{ J}$$

261. A man throws a ball of mass 3.0 kg with a speed of 5.0 ms^{-1}. His hand is in contact with the ball for 0.2 s. If the throws 4 balls in 2 seconds, the average force exerted by him in 1 second is

(a) 15 N (b) 30 N

(c) 150 N (d) 75 N

AMU-2018

Ans. (b) : Given,

Mass of the ball (m) = 3 kg

Speed (v) = 5 m/s

Time taken by the man to throw a ball is,

$$\Delta t = \frac{2}{4} = 0.5\text{s}$$

Change in momentum of the ball = Mass × Speed

= m.v

= 3 × 5

= 15 Ns

Force = Rate of change in linear momentum

$$F = \frac{\Delta p}{\Delta t} = \frac{15}{0.5} = 30\text{ N}$$

262. A force of 10 N acts on a body of mass 0.5 kg for 0.25s starting from rest. What is its momentum now?

(a) 0.25 N-s (b) 2.5 N-s

(c) 0.5 N-s (d) 0.75 N-s

JIPMER-2018

Ans. (b) : Given, F = 10 N, m = 0.5 kg and t = 0.25 sec

We know that,

Momentum (p) = mv ….(i)

Then,

Force (F) = ma

$$\text{Acceleration}\,(a) = \frac{F}{m} = \frac{10}{0.5} = 20\,\text{m/s}^2$$

From the Newton's first law of motion

$\therefore \quad v = u + at$

$= 0 + 20 \times 0.25$

$= 5$ m/s

Then, from equation (i)

$p = 0.5 \times 5$

$= 2.5$ N-s

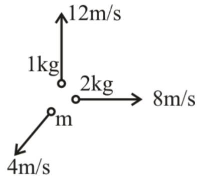
263. An explosion breaks a rock into three parts in a horizontal plan. Two of them go off at right angles to each other. The first part of mass 1 kg moves with a speed of 12 ms^{-1} and the second part of mass 2 kg moves with speed 8 ms^{-1}. If the third part files off with speed 4 ms^{-1} then its mass is

(a) 5 kg (b) 7 kg

(c) 17 kg (d) 3 kg

AIIMS-27.05.2018(M)

Ans. (a) :



@apna_pdf

Here, an explosion breaks a rock into three parts in a horizontal plain,

Given,

Two parts of Mass $m_1 = 1kg$

Mass $m_2 = 2kg$

Speed $V_1 = 12m/s$

$V_2 = 8m/s$

So, linear momentum of first part

$P_1 = m_1V_1$

$= 1\times12 = 12$ kg m/s

linear momentum of second part

$P_2 = m_2\times V_2$

$= 2\times8 = 16$ kg m/s

$$P_{resultant} = \sqrt{P_1^2 + P_2^2 + 2P_1P_2\cos\theta}$$

$$= \sqrt{(12)^2 + (16)^2 + 2\times12\times16\cos90^o}$$

$$= \sqrt{144+256}$$

$$= \sqrt{400}$$

$$= 20kg\,m/s \qquad .... (i)$$

Now,

Linear momentum of third part

$P_3 = m_3\times V_3$

$= 4m_3 \qquad ....(ii)$

Initial momentum of rock = mass × speed

$= m\times0$

$= 0$ kg m/s

By conservation of momentum,

Initial momentum = Final momentum

$0 = P_1 + P_2 + P_3$

$P_3 = -(P_1+P_2) \qquad ....(iii)$

Now,

Substitute the value of P_1, P_2 and P_3 from above in equation (iii) we get,

$4m_3 = 20$

$m_3 = \dfrac{20}{4}$

$= 5kg$

264. A machine gun can fire 200 bullets/min. If 35 g bullets are fired at a speed of 750 m/s, then the average force exerted by the gun on the bullets is

(a) 87.5 N (b) 26.2 N

(c) 78.9 N (d) 110.3 N

TS-EAMCET-04.05.2018, Shift-1

Ans. (a) : Mass of bullet = 35 g = $\dfrac{35}{1000}$kg

Number of bullets per second = $\dfrac{200}{60} = \dfrac{10}{3}$

Speed of bullet = 750 m/s

∴ Force exerted by gun on bullets,

$$F = \frac{35}{1000}\times\frac{10}{3}\times750 = 35\times2.5 = 87.5N$$

265. Assertion: A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical.

Reason: The rate of change of momentum determines that the force is small or large.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(E)

Ans. (a) : In a quick collision, time is small as F × t = constant therefore, force involved is large in collision is more violent in compression to slow collision.

Hence, due to greater momentum quicker collision between two bodies will be more violent even initial and final velocities are identical.

266. Why there are two propellers in a helicopter?

(a) Due to conservation of linear momentum, the helicopter itself would have turned in the opposite direction, if it had only one propeller

(b) Due to conservation of angular momentum, the helicopter itself would have turned in the opposite direction, if it had only one propeller

(c) The helicopter can't rise up with one propeller

(d) The helicopter would not gain speed with one

J&K-CET-2018

Ans. (b) : If the helicopter had only one propeller, then due to conservation of angular momentum, the helicopter itself would turn in the opposite direction.

267. Assertion: Linear momentum of body changes even when it is moving uniformly in a circle.

Reason: In uniform circular motion, velocity remains constant.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(M)

Ans. (c) : As we know,

$p = mv$

Where, p = Linear momentum

m = Mass of body

v = Velocity of body

In uniform circular motion, the direction of motion changes so the linear momentum of body changes. As p ∝ v so the velocity of the body also change.

268. A ball of mass 10 g moving perpendicular to the plane of the wall strikes it and rebounds in the same line with the same velocity. If the impulse experienced by the wall is 0.54 Ns, the velocity of the ball is

(a) 27 ms^{-1} (b) 3.7 ms^{-1}

(c) 54 ms^{-1} (d) 37 ms^{-1}

AIIMS-27.05.2018(E)

@apna_pdf

Ans. (a): Given,
Mass of the ball (m) = 10g = 0.01kg
Impulse experienced by wall = 0.54 Ns
As the ball rebounds in the same line with the same velocity after striking the wall then
Vhange in momentum (ΔP)= –mv – (mv)
$= -2\text{ mv}$
$|\Delta P| = 0.02\text{ v}$
We know that,
$\because$ Impulse = change in momentum
$I = \Delta P$
$0.54 = 0.02v$
$v = 27\text{m/s}.$

269. A body of mass M hits normally a rigid wall with velocity V and bounces back with the same velocity. The impulse experienced by the body is

(a) MV
(b) 1.5 MV
(c) 2 MV
(d) zero

BITSAT-2018

Ans. (c) : Impulse is defined as the change in momentum in very small time. Let initially the body is moving along positive x-axis with speed v.
So, momentum of the body finally-

$$\vec{P}_i = MV\hat{i}$$

After bouncing back, the body moves along negative x-axis with same speed.
So, momentum of the body finally-

$$\vec{P}_f = -MV\hat{i}$$

Thus change in momentum of body,

$$\Delta\vec{P} = \vec{P}_f - \vec{P}_i = 2MV\hat{i}$$

$$\text{Impulse experienced } = \Delta\vec{P}$$
$$= \left|\vec{P}_f - \vec{P}_i\right|$$
$$= \left|(-MV) - (MV)\right|$$
$$= 2\text{ MV}$$

270. A body of mass 2 kg makes an elastic collision with another body at rest and continues to move in the original direction with one-fourth its original speed. The mass of the second body which collides with the first body is

(a) 2 kg
(b) 1.2 kg
(c) 3 kg
(d) 1.5 kg

Manipal UGET-2018

Ans. (b) : Given that,
Mass of the first body (m_1) = 2kg
Let initial velocity of the first body (u_1) = u
According to question, the velocity of the first body-

$$v_1 = \frac{u}{4}$$

Assume mass of second body (m_2) = m
The initial velocity of the second body (u_2) = 0
The velocity of the second body (v_2) = ?
By using the conservation of linear momentum and total energy for head-on elastic collision, we have

$$v_1 = \frac{(m_1 - m_2)u_1}{m_1 + m_2} + \frac{2m_2u_2}{m_1 + m_2}$$
$$\frac{u}{4} = \frac{(2-m)u}{2+m} + \frac{2\times m\times 0}{2+m}$$
$$\frac{u}{4} = \frac{(2-m)u}{2+m}$$
$$2 + m = 8 - 4m$$
$$5m = 6$$
$$m = \frac{6}{5} = 1.2\text{kg}$$

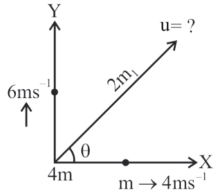
Hence, the mass of the second body m = 1.2 kg

271. A particle of mass 4 m which is initially at rest explodes into three pieces of masses m, m and 2m. The equal masses move along X and Y-axes with velocities 4 ms^{-1} and 6 ms^{-1}, respectively. The magnitude of the velocity of the heavier mass is

(a) $\sqrt{17}\text{ms}^{-1}$
(b) $2\sqrt{13}\text{ms}^{-1}$
(c) $\sqrt{13}\text{ms}^{-1}$
(d) $\frac{\sqrt{13}}{2}\text{ms}^{-1}$

AP EAMCET (23.04.2018) Shift-1
JCECE-2005

Ans. (c) : Given,
Mass of particle along X and Y direction ($m_1 = m_2$) = m
Mass of third particle = 2m
Velocity of particle in X-direction (v_1) = 4 ms^{-1}
Velocity of particle in Y-direction (v_2) = 6 ms^{-1}



Using conservation of linear momentum in X-direction-

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $\left[\begin{array}{l}\because \text{ Particle is at initially rest}\\ \therefore\ u_1 = u_2 = 0\end{array}\right]$

$$0 = m\times 4 + 2m(u\cos\theta)$$
$$u\cos\theta = -2 \qquad \text{.....(i)}$$

Again using law of conservation of linear momentum in Y- direction-

$$0 = m\times 6 + 2m(u\sin\theta)$$
$$\frac{-6}{2} = u\sin\theta$$
$$u\sin\theta = -3 \qquad \text{....(ii)}$$

Squaring both equation (i) and (ii) and adding, we get-

$$u^2\cos^2\theta + u^2\sin^2\theta = (-2)^2 + (-3)^2$$
$$u^2(\cos^2\theta + \sin^2\theta) = 13$$
$$u^2 = 13$$
$$u = \sqrt{13}\text{ m/s}$$

@apna_pdf

272. A body of mass 10 kg is being acted upon by a force of $3t^2$ N and an opposing constant force of 30 N. The initial speed is 10 ms^{-1}. The velocity of the body after 5 seconds is

(a) 12.5 ms^{-1} (b) 7.5 ms^{-1}
(c) 5 ms^{-1} (d) 2.5 ms^{-1}

AP EAMCET-28.04.2017, Shift-II

Ans. (b) : Given, m = 10 kg

Net Force on the body,

$F_{net} = 3t^2 - 30$

$$\text{Acceleration, } a = \frac{F}{m} = \frac{3t^2 - 30}{10}$$

$$a = 0.3t^2 - 3$$

We know that,

$$a = \frac{dv}{dt}$$

So, dv = a dt

$$\frac{dv}{dt} = 0.3t^2 - 3$$

$$dv = 0.3t^2 . dt - 3dt$$

$$\int_{10}^{v} dv = 0.3\int_0^5 t^2 . dt - 3\int_0^5 dt$$

$$[v]_{10}^{v} = 0.3 \times \left[\frac{t^3}{3}\right]_0^5 - 3[t]_0^5$$

$$(v-10) = 0.3 \times \left(\frac{5^3}{3}\right) - 3(5)$$

$$(v-10) = 0.3 \times \left(\frac{125}{3}\right) - 3(5)$$

$v - 10 = 12.5 - 15$

$v = 22.5 - 15$

$v = 7.5 ms^{-1}$

273. A disc of mass 100g is kept floating horizontally in air by firing bullets, each of mass 5g with the same velocity at the same rate of 10 bullets/sec. The bullets rebounds with the same speed in opposite direction the velocity of each bullet at the time of impact is

(a) 196 cm s^{-1} (b) 9.8 cm s^{-1}
(c) 98 cm s^{-1} (d) 980 cm s^{-1}

BCECE-2017

Ans. (d) : Given,

Mass of Disc (m_1) = 100g

Mass of each bullet (m_2) = 5g

Let the velocity of bullet = v m/s

As the disc is floating horizontally in the air due to hit of bullet

so, change in momentum of n bullet = gravitational force applied on disc

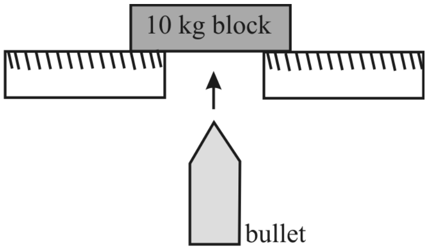
$$n\{m_2 v - (-m_2 v)\} = m_1 g$$

$$2m_2 v \times n = m_1 g$$

$$2 \times 5 \times v \times 10 = 100 \times 980$$

$v = 980$ cm/s

274. A 10 g bullet moving directly upward at 1000 m/s strikes and passes through the center of mass of a 10 kg block initially at rest. The bullet emerges from the block moving directly upward at 400 m/s. What will be velocity of the block just after the bullet comes out of it?



(a) 1 m/s (b) 0.4 m/s
(c) 1.4 m/s (d) 0.6 m/s

UPSEE - 2017

Ans. (d) : Given that,

Weight of bullet (m_B) = 10g = 10 $\times 10^{-3}$ kg

Weight of block (m_b) = 10 kg

Velocity of block (v_b) = ?

Initial velocity of bullet (v_i) = 1000 m/s

Final velocity of bullet (v_f) = 400 m/s

By the law of conservation of momentum,

$$m_B v_i = m_B v_f + m_b v_b$$

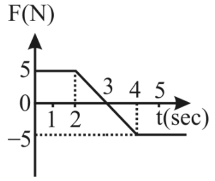
$$(10 \times 10^{-3})\ (1000) = (10 \times 10^{-3})\ (400) + 10v_b$$

$$10 = 4 + 10v_b$$

$$10v_b = 6$$

$$v_b = \frac{6}{10} = 0.6 m/s$$

275. A block of mass of 1 kg is moving on the x-axis. A force F acting on the block is shown. Velocity of the block at time t = 2 s is –3 m/s. What is the speed of the block at time t = 4s?



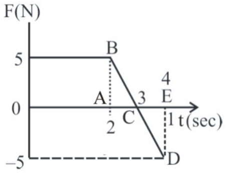
(a) 8 m/s (b) 2 m/s
(c) 3 m/s (d) 5 m/s

UPSEE - 2017

Ans. (c) : Given that,

Mass of block (m) = 1 kg

Velocity of block is –3 m/s at t = 2



From the graph,

Impulse (J) = Area of ΔABC + Area of ΔCDE

$$= \frac{1}{2} \times (3-2) \times 5 + \frac{1}{2}(4-3) \times (-5)$$

@apna_pdf

$= \frac{1}{2}\times1\times5+\frac{1}{2}\times1\times(-5)$

$=\frac{5}{2}-\frac{5}{2}=0$

We know that,

Impulse = Change in momentum

$0 = mv_f - mv_i$

$v_f = v_i = -3\text{m/s}$

or $\therefore |v_f| = 3$ m/s

276. A shell at rest at the origin explodes into three fragments of masses 1 kg, 2 kg and m kg. The 1 kg and 2 kg pieces fly off with speeds of 5 ms^{-1} along x-axis and 6ms^{-1} along y-axis respectively. If the m kg piece flies off with a speed of 6.5 ms^{-1}, the total mass of the shell must be

(a) 4 kg (b) 5 kg

(c) 3.5 kg (d) 4.5 kg

(e) 5.5 kg

Kerala CEE 2007

Ans. (b) : Let the mass of the shell be M which will be the sum of the masses of the fragments f_1, f_2 and f_3.

Mass of f_1 = 1kg, f_2 = 2 kg, f_3 = m kg

M = 1 + 2 + m = 3 + m

Linear momentum of the fragments $p_{f_1} = 1 \times 5$

$= 5$ kg-m/s

$p_{f_2} = 2 \times 6 = 12$ kg-m/s

$p_{f_3} = m \times 6.5 = 6.5m$ kg-m/s

Since the fractions f_1 and f_2 flies along the x-axis and y–axis (at 90° to each other)

The vector sum of their linear momentum will be

$5\hat{i}+12\hat{j}=5^2+12^2$

$(6.5m)^2 = (13)^2$

$m = \frac{13}{6.5} = 2\text{kg}$

Total mass (M) = 1 + 2 + m

M = 1+ 2 + 2 = 5 kg

277. A 20 kg ball moving with a velocity 6 m/s collides with a 30 kg ball initially at rest. If both of them coalesce, then the final velocity of the combined mass is:

(a) 6 m/s (b) 5 m/s

(c) 3.6 m/s (d) 2.4 m/s

(e) 1.2 m/s

Kerala CEE 2006

Ans. (d) : Given, $m_1 = 20$ kg, $m_2 = 30$kg

$u_1 = 6\text{m/s}, u_2 = 0$

Using law of conservation of momentum–

$m_1u_1 + m_2u_2 = v(m_1 + m_2)$

$20 \times 6 + 0 = v (20 + 30)$

$50v = 120$

$v = \frac{120}{50} = 2.4\text{m/s}$

278. A 10kg object collides with stationary 5kg object and after collision they stick together and move forward with velocity 4ms^{-1}. What is the velocity with which the 10kg object hit the second one?

(a) 4 ms^{-1} (b) 6 ms^{-1}

(c) 10 ms^{-1} (d) 12 ms^{-1}

(e) 14 ms^{-1}

Kerala CEE 2004

Ans. (b) : Given, $m_1 = 10$kg, u_1 = ?

$m_2 = 5$kg, $u_2 = 0$ m/s, v = 4m/s

Using law of conservation of momentum–

$m_1u_1 + m_2u_2 = v(m_1 + m_2)$

$10 \times u_1 + 0 = 4(10 + 5)$

$u_1 = 6$ m/s

279. The recoil velocity of 4.0 kg rifle that shoots a 0.050 kg bullet at a speed of 280 ms^{-1} is:

(a) + 3.5 ms^{-1} (b) – 3.5 ms^{-1}

(c) $-\sqrt{(3.5)}$ ms^{-1} (d) $+\sqrt{(3.5)}$ms^{-1}

(e) + 7 ms^{-1}

Kerala CEE 2004

Ans. (b) : Given that, $m_1 = 4$kg, $m_2 = 0.050$ kg, $u_2 = 280$m/s, u_1 = ?

By the law of conservation of momentum–

$m_1 u_1 + m_2 u_2 = 0$

$u_1 = -\frac{m_2u_2}{m_1}$

$= -\frac{0.050\times280}{4} = -3.5\text{m/s}$

280. A bomb at rest explodes into 3 parts of the same mass. The momentum of the 2 parts is $-2p\hat{i}$ and $p\hat{j}$. The momentum of the third part will have a magnitude of :

(a) p (b) $\sqrt{3}$p

(c) $p\sqrt{5}$ (d) zero

UPSEE - 2005

Ans. (c) : Given,

$\vec{P}_1 = (-2p\hat{i})$ and $\vec{P}_2 = p\hat{j}$

$m_1 = m_2 = m_3 = \frac{m}{3}$

initial momentum = 0

Let momentum of third part be $\vec{P}_3$

Using principle of conservation of linear momentum:

$\vec{P}_f = \vec{P}_i$

$\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0$

$-2p\hat{i} + p\hat{j} + \vec{P}_3 = 0$

$\vec{P}_3 = 2p\hat{i} - p\hat{j}$

$P_3 = \sqrt{(2p)^2 + (p)^2}$

$P_3 = p\sqrt{5}$

@apna_pdf

281. A 5 kg stationary bomb is exploded in three parts having mass 1:1:3 respectively. Parts having same mass move in perpendicular directions with velocity 39 m/s, then the velocity of the bigger part will be :

(a) $10\sqrt{2}\,\text{m/s}$ (b) $\frac{10}{\sqrt{2}}\,\text{m/s}$

(c) $13\sqrt{2}\,\text{m/s}$ (d) $\frac{15}{\sqrt{2}}\,\text{m/s}$

BCECE-2005
UPSEE - 2004

Ans. (c) : $\because$ m + m + 3m = 5 kg

$m = 1\text{kg or } 3m = 3\text{kg}$

$P_i = 0$

Law of conservation of momentum,

$P_i = P_f \Rightarrow 1\times0 = (1\times39)\,i + (1\times39)j + 3v$

$3v = -39\hat{i} - 39\hat{j}$

$$3|v| = \sqrt{(39)^2 + (39)^2 + 2\times39\times39\times0}$$

$$3|v| = 39\sqrt{2}$$

$$v = 13\sqrt{2}\,\text{m/s}$$

282. When the speed of a moving body is doubled :

(a) its acceleration is doubled
(b) its momentum is doubled
(c) its kinetic energy is doubled
(d) its potential energy is doubled

UPSEE - 2004

Ans. (b) : By linear momentum equation,

$p = mv$

$\because \quad p_1 = mv_1 ,\ p_2 = m\,(2v_1)$

$$\therefore \quad \frac{p_1}{p_2} = \frac{mv_1}{2mv_1} = \frac{1}{2}$$

$p_2 = 2p_1$

From the above equation it is clear that the if velocity is doubled then the momentum also doubled.

283. A shell explodes and many pieces fly off in different directions. The following is conserved:

(a) Kinetic energy
(b) Momentum
(c) Neither momentum nor KE
(d) Momentum and KE

BITSAT-2007

Ans. (b) : We know that, conservation of momentum states that the amount of momentum of the system remains constant before and after explosion, as momentum neither be created nor be destroyed.

In this question, let us consider the shell of mass M and velocity v or explosion divides itself into 3 parts of masses m_1, m_2 and m_3 having velocities v_1, v_2, v_3 respectively.

Now, the momentum of an object is—

$mv = m_1 v_1 + m_2 v_2 + m_3 v_3$

This indicates that momentum is conserved.

284. A man of mass 100 kg is standing on a platform of mass 200 kg which is kept on a smooth ice surface. If the man starts moving on the platform with a speed 30 m/sec relative to the platform then calculate with what velocity relative to the ice the platform will recoil?

(a) 5 m/sec (b) 10 m/sec
(c) 15 m/sec (d) 20 m/sec

BITSAT-2012

Ans. (b) : Given that,

Mass of man (m) = 100 kg
Mass of platform (M) = 200 kg

Man velocity relative to platform (v) = 30 m/sec
Velocity of platform relative to ice (V) = ?
We know that,

$MV = m(v - V)$

$MV = mv - mV$

$MV + mV = mv$

$V(M+m) = mv$

$$V = \frac{mv}{(M+m)}$$

$$V = \frac{100\times30}{200+100}$$

$$V = \frac{3000}{300}$$

V = 10 m/s

285. A rifle man, who together with his rifle has a mass of 100 kg, stands on a smooth surface and fires 10 shots horizontally. Each bullet has a mass 10 g and a muzzle velocity of 800 ms^{-1}. The velocity which the rifle man attains after firing 10 shots is

(a) 8 ms^{-1} (b) 0.8 ms^{-1}
(c) 0.08 ms^{-1} (d) –0.8 ms^{-1}

BITSAT-2014

Ans. (b) : Given that,

Mass of rifle (m) = 100 kg
Man velocity relative to rifle V = ?
Mass of bullet = $10 \times 10 \times 10^{-3}$ kg = 0.1 kg
Velocity of muzzle = 800 ms^{-1}

According to law of conservation of momentum-

$P_{\text{initial}} = P_{\text{final}}$

$$100 \times V = \frac{1}{10}\times800$$

$$V = \frac{80}{100} = 0.8\,\text{m/s}$$

286. A bullet of mass 10 g is fired from a gun of mass 1 kg with recoil velocity of gun is 5 m/s. The muzzle velocity will be

(a) 30 km/min (b) 60 km/min
(c) 30 m/s (d) 500 m/s

Manipal UGET-2012

Ans. (d) : Given,

Mass of bullet (m_b) = 10 g = 0.01 kg
Mass of gun (m_g) = 1 kg
Velocity of gun (v_g) = 5 m/s

@apna_pdf

The muzzle velocity (v_b) = ?

By using the conservation of linear momentum,

$$m_b v_b = m_g v_g$$

$$v_b = \frac{1\times5}{0.01} = 500\,\text{m/s}$$

287. A bullet of mass 10 g moving horizontally at a speed of 140 m/s strikes a block of mass 100 g attached to a string like a simple pendulum. The bullet penetrates the block and emerges then on the other side. If the block rises by 80 cm, then find the final velocity of bullet.

(a) 80 m/s (b) 100 m/s
(c) 120 m/s (d) 140 m/s

JCECE-2016

Ans. (b) : Given,

Mass of bullet (m) = 10gm = 0.01kg

Mass of wooden block (M) = 100 gm = 0.1kg

Velocity of the bullet with which it strikes (u) = 140 m/s

From law of conservation of linear momentum-

$$0.01\times140 + 0.1\times0 = 0.1v_1 + 0.01v_2$$

$$0.01(140) = 0.01(10v_1 + v_2)$$

$$140 = 10v_1 + v_2 \qquad \text{....(i)}$$

From third equation of motion,

$$v^2 = u^2 + 2gh$$

$$0 = v_1^2 - 2g\left(\frac{80}{100}\right) \qquad [\because v = 0]$$

$$v_1^2 = 2\times10\times0.8$$

$$v_1 = 4\,\text{m/s}$$

Putting the value of v_1 in equation (i), we get-

$$140 = 10\times4 + v_2$$

$$v_2 = 100\ \text{m/s}$$

288. A body of mass 2 kg is projected from the ground with a velocity 20 ms^{-1} at an angle 30° with the vertical. If t_1 is the time in second at which the body is projected and t_2 is the time in second at which it reaches the ground, the change in momentum in kgms^{-1} during the time (t_2–t_1) is

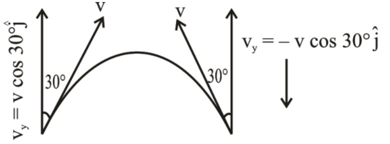
(a) $40\sqrt{2}$ (b) $40\sqrt{3}$
(c) $25\sqrt{3}$ (d) 45

JCECE-2014

Ans. (b) : Given,

v = 30 m/s

m = 2kg



$$\Delta p = m\Delta\vec{v}$$

$$= m\left(-v\cos30°\hat{j} - v\cos30°\hat{j}\right)$$

$$= -2mv\cos30°\hat{j}$$

$$= -2m\frac{\sqrt{3}}{2}v\hat{j}$$

$$\Delta\vec{p} = -2\times2\times\frac{\sqrt{3}}{2}\times20\hat{j}\ \text{kg-m/s}$$

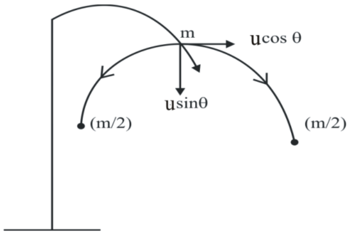
$$|\Delta\vec{p}| = 40\sqrt{3}\,\text{kg-m/s}$$

289. A body just dropped from a tower explodes into two pieces of equal mass in mid-air. Which of the following is not possible?

(a) Each part will follow parabolic path
(b) Only one part will follow parabolic path
(c) Both parts move along a vertical line
(d) One part reaches the grounds earlier than the other

JCECE-2011

Ans. (b) :



If a body just dropped from a tower then the velocity acquired due to implosions are in vertical direction so-both parts move along a vertical line and one part reaches the ground earlier than the other.

So option (c) and (d) are possible.

If one of them follows parabolic path then other also acquire parabolic path because both have horizontal velocity.

So, we can say option (b) is not possible.

290. A 5000 kg rocket is set for vertical firing. The exhaust speed is 800 m/s. To give an initial upward acceleration of 20 m/s^2, The amount of gas ejected per second to supply the needed thrust will be:

(a) 137.5 kg/s (b) 185.5 kg/s
(c) 127.5 kg/s (d) 187.5 kg/s

JCECE-2005

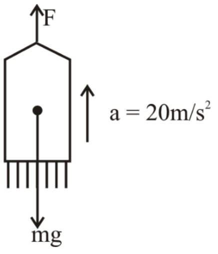
Ans. (d) : Given,

Mass of rocket (m) = 5000 kg

Speed of exhaust (v) = 800 m/s

Acceleration of rocket (a) = 20 m/s^2

We assume that the amount of gas ejected per second be $\frac{dm}{dt}$.



Up thrust force = $\frac{d}{dt}(mv) = \frac{dm}{dt}v$

$$F_{up} - mg = ma$$

$$\therefore F_{net} = \frac{dm}{dt}v - mg = ma$$

@apna_pdf

$$\frac{dm}{dt}\times 800-5000\times 10=5000\times 20$$

or $$\frac{dm}{dt}-62.5=125$$

or $$\frac{dm}{dt}=187.5\ kg/s$$

291. A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. Then the speed of the system after collision is:

(a) 2v (b) $\frac{v}{2}$

(c) 3v (d) $\frac{v}{3}$

AIIMS-1999

J&K CET- 1999

Ans. (d) : Given,

Before collision-

$m_1 = m,\ \ m_2 = 2\ m$

$v_1 = v\ \ \ v_2 = 0$

After collision-

$v_3 = ?,\ \ m_3 = (m+2m) = 3\ m$

Applying law of conservation of momentum-

$P_1 + P_2 = P_3$

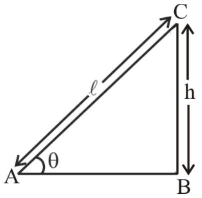
$m_1v_1 + m_2v_2 = m_3v_3$

$mv + 2\ m \times 0 = 3m \times v_3$

or $v_3 = \frac{v}{3}$

Speed of the system after collision is $\frac{v}{3}$.

292. A smooth inclined plane is inclined at an angle θ with horizontal. A body starts from rest and slides down the inclined surface.



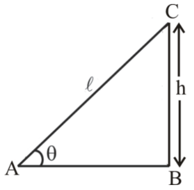
Then the time taken by it to reach the bottom is

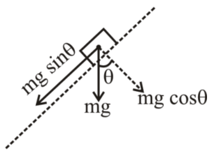
(a) $\sqrt{\left(\frac{2h}{g}\right)}$ (b) $\sqrt{\left(\frac{2\ell}{g}\right)}$

(c) $\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$ (d) $\sin\theta\frac{\sqrt{(2h)}}{g}$

AIIMS-2015

Ans. (c) : Given, the initial velocity of body will be zero because body moves from rest i.e. u = 0





According to second law of motion-

$$s = ut + \frac{1}{2}\ a\,t^2$$

Here, $s = l,\quad a = g\sin\theta$

$$\therefore\quad l = 0\times t + \frac{1}{2}(g\sin\theta)\times t^2$$

$$t = \sqrt{\frac{2l}{g\sin\theta}}\qquad \ldots(i)$$

In ΔBAC -

$$\sin\theta = \frac{h}{l}$$

$$l = \frac{h}{\sin\theta}$$

Putting the value of l in equation (i), we get-

$$t = \sqrt{\frac{\frac{2\times h}{\sin\theta}}{g\ \sin\theta}}$$

or $$t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$$

293. A 150 g tennis ball coming at a speed of 40 m/s is hit straight back by a bat to a speed of 60 m/s. The magnitude of the average force F on the ball, when it is in contact for 5 ms, is:

(a) 2500 N (b) 3000 N

(c) 3500 N (d) 4000 N

AIIMS-2011

Ans. (b) : Given,

$v_1 = 40\ m/s\ ,\ v_2 = 60\ m/s$

$\Delta t = 5\ ms = 5 \times 10^{-3}\ sec$

$m = 150g = 1.5 \times 10^{-1}\ kg\ ,\ F_{avg} = ?$

We know that,

$$\because\quad F_{avg} = \frac{\Delta P}{\Delta t}$$

$$F_{avg} = m\left(\frac{v_2 - v_1}{\Delta t}\right)$$

$$F_{avg} = m\times\frac{(-60-40)}{5\times 10^{-3}}$$

$$F_{avg} = \frac{-1.5\times 10^{-1}\times 100}{5\times 10^{-3}} = -3000\ \ N$$

Therefore, the magnitude of the average force on the ball is 3000 N.

294. A gun fires a bullet of mass 50 g with a velocity of 30 m/s. Due to this, the gun is pushed back with a velocity of 1 m/s, then the mass of the gun is:

(a) 1.5 kg (b) 5.5 kg

(c) 0.5 kg (d) 3.5 kg

AIIMS-2001

Ans. (a) : Given,

Mass of bullet $(m_1) = 50g = 0.05\ kg$

Mass of gun $= m_2$

Velocity of bullet $(v_1) = 30\ m/s$

@apna_pdf

Velocity of gun (v_2) = 1 m/s

Applying law of conservation of momentum-

$m_1v_1 = m_2v_2$

$0.05 \times 30 = m_2 \times 1$

$m_2 = 1.5$ kg

295. A molecule of mass m of an ideal gas collides with the wall of the vessel with the velocity v and returns back with the same velocity. The change in the magnitude of linear momentum of the molecule will be:

(a) 4 mv (b) 8 mv

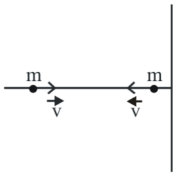
(c) 2 mv (d) –2 mv

AIIMS-1997

Ans. (c) : Given,

Mass of molecule = m

Velocity of molecule = v



Molecule returns back i.e. θ = 0°

∵ Initial moment $\left(\vec{P}_1\right) = mv\cos 0^\circ = mv$

And Final momentum $\left(\vec{P}_2\right) = (-mv\cos 0^\circ) = -mv$

∴ Change in momentum $\left(\Delta\vec{P}\right) = \vec{P}_2 - \vec{P}_1$

$= -mv - mv$

$= -2mv$

Thus magnitude of change of linear momentum $|\Delta\vec{P}| = \sqrt{(-2mv)^2} = 2mv$

296. A girl of mass 50 kg standing on a rail road car of mass 75 kg moving with velocity 20m/s. Now, the girl begins to run with velocity of 10 m/s with respect to the car in the same direction, as that of the car. Velocity of the car at this instant will be–

(a) 20 m/s (b) 24 m/s

(c) 16 m/s (d) 18 m/s

BCECE-2016

Ans. (c) : Given,

Mass of girl (m_1) = 50 kg

Mass of rail road car (m_2) = 75 kg

Initial velocity of girl (u_1) = 20 m/s

Initial velocity of car (u_2) = 20 m/s

Final velocity of car (v_2) = v

Velocity of the girl with respect to car is 10 m/s

So, final velocity of the girl as by the observer-

$v_1 = (v+10)$ m/s

By the law of conservation of momentum-

$P_i = P_f$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$50 \times 20 + 75 \times 20 = 50 \times (v+10) + 75 \times v$

$2500 = 500 + 125v$

$v = 16$ m/s

297. A bomb of mass 3.0 kg explodes in air into two pieces of masses 2.0 kg and 1.0 kg. The smaller mass goes at a speed of 80 m/s. The total energy imparted to the two fragments is-

(a) 1.07 kJ (b) 2.14 kJ

(c) 2.4 kJ (d) 4.8 kJ

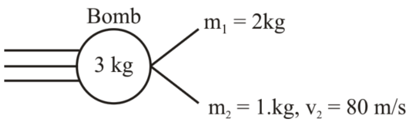
BCECE-2008

Ans. (d) : Given, mass of the bomb (m) = 3 kg

After explosion-

Mass of 1st piece (m_1) = 2 kg

and Mass of 2nd piece (m_2) = 1 kg



Initially, bomb is at rest so initial momentum (P_i) = 0

According to law of conservation of momentum-

$P_i = P_f$

$0 = m_1v_1 + m_2v_2$

$0 = 2 \times v + 1 \times 80$

$v_1 = -40$ m/s

Negative sign indicates that both particles move in opposite direction.

$$\text{Total kinetic energy} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$= \frac{1}{2}\times 2\times(40)^2 + \frac{1}{2}\times 1\times(80)^2$$

$= 1600 + 3200 = 4800$ J

$= 4.8$ kJ

298. A nucleus at rest splits into two nuclear parts having radii in the ratio 1:2. Their velocities are in the ratio :

(a) 4 : 1 (b) 8 : 1

(c) 2 : 1 (d) 6 : 1

Karnataka CET-2015

Ans. (b) : Given,

$$\frac{r_1}{r_2} = \frac{1}{2}$$

As we know that if both parts originated from the same nucleus so their density will be equal. Since, densities are equal so the mass of the parts are in the ratio of the volume. Volume is directly proportional to the cube of radius so we can write–

$$\frac{V_1}{V_2} = \frac{m_1}{m_2} = \frac{r_1^3}{r_2^3}$$

or $\frac{m_1}{m_2} = 1:8$ …(i)

From the conservation of the momentum-

$m_1v_1 = m_2v_2$

or $\frac{v_1}{v_2} = \frac{m_2}{m_1}$

Putting the value from equation (i), we get-

$$\frac{v_1}{v_2} = 8:1$$

@apna_pdf

299. A gun fires a small bullet with kinetic energy K. Then kinetic energy of the gun while recoiling is:

(a) K (b) more than K

(c) less than K (d) $\sqrt{K}$

Karnataka CET-2013

Ans. (c) : Let, the kinetic energy of the gun be K initially the system is at rest and so the momentum of the system is zero and according to the law of conservation of momentum, the final momentum should be also zero.

Therefore by the relation-

$$K=\frac{1}{2}mv^2$$

$$K=\frac{1}{2}\frac{(mv)^2}{m}$$

$$K=\frac{1}{2}\frac{p^2}{m}$$

$$K\propto\frac{1}{m}\text{ (as momentum is same)}$$

Hence, as the mass of gun is greater, its kinetic energy will be less.

300. A body a rest breaks into two pieces with unequal mass

(a) both of them have equal speeds

(b) both of them move along a same line with unequal speeds

(c) sum of their momentum is non zero

(d) they move along different lines with different speeds

J&K CET- 2006

Ans. (b) : Let m_1 be the mass of the first part and m_2 be the mass of second part.

According to the conservation of momentum-

$$m_1v_1 + m_2v_2 = 0$$

or $$m_1v_1 = -m_2v_2$$

$$v_1=\frac{-m_2}{m_1}v_2$$

So, $v_1 \neq v_2$ and also opposite direction

So, they have unequal mass, they will move with unequal speeds and along same lines.

301. A body of mass 4 kg moving with velocity 12 m/s collides with another body of mass 6 kg at rest. If two bodies stick together after collision, then the loss of kinetic energy of system is

(a) zero (b) 288 J

(c) 172.8 J (d) 144 J

J&K CET- 2005

Ans. (c) : Given,

Before collision,

$$m_1 = 4\text{ kg},\ m_2 = 6\text{ kg},\ v_1 = 12\text{ m/s},\ v_2 = 0\text{ m/s}$$

After collision,

$$(m_1 + m_2) = 4+6 = 10\text{ kg},$$

$$\text{Loss in kinetic energy}=\frac{1}{2}\frac{m_1m_2}{(m_1+m_2)}(v_1-v_2)^2$$

$$=\frac{1}{2}\times\frac{4\times6}{(4+6)}(12-0)^2$$

$$= 172.8\text{J}$$

302. A body of mass 5 kg strikes another body of mass 2.5 kg initially at rest. The bodies after collision coalesce and begin to move as a whole with a kinetic energy of 5 J. The kinetic energy of the first body before collision is

(a) 7.5 J (b) 5 J

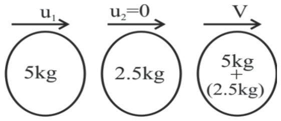
(c) 2.5 J (d) 10 J

J&K CET- 2003

Ans. (a) : Given,

$$m_1 = 5\text{kg},\ m_2 = 2.5\text{kg},\ u_2 = 0$$

Let u_1 be velocity of body of mass 5 kg, and u_2 of 2.5 kg. Then,



Momentum before collision = momentum after collision

$$m_1u_1 + m_2u_2 = (m_1 + m_2)\ v_1$$

$$5u_1 = (5 + 2.5)\ v$$

$$u_1 = \frac{7.5}{5}v = 1.5v \qquad \text{.......... (i)}$$

Also, Kinetic energy after collision

$$5=\frac{1}{2}(m_1+m_2)v^2 \qquad \text{..........(ii)}$$

$$5=\frac{(5+2.5)v^2}{2}$$

$$10 = 7.5v^2$$

Putting the value from equation (i), we get

$$10=7.5\left(\frac{5u_1}{7.5}\right)^2$$

$$u_1^2=3$$

K.E of 1st body before collision

$$=\frac{1}{2}m_1u_1^2=\frac{1}{2}\times5\times3=\frac{15}{2}=7.5\text{ J}$$

303. The linear momentum is conserved in

(a) elastic collisions (b) inelastic collisions

(c) both 1 and 2 (d) neither 1 nor 2

J&K-CET-2013

Ans. (c) : In all types of collision, total linear momentum of colliding particle remains conserved.

304. In an explosion a body breaks up into pieces of unequal masses. In this case

(a) both parts will have numerically equal momentum

(b) lighter part will have more momentum

(c) heavier part will have more momentum

(d) both part will have equal kinetic energy

Manipal UGET-2011

@apna_pdf

Ans. (a) : According to the law of conservation of momentum, for a collision occurring between object 1 and object 2 in an violated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision.

So, it is clear that momentum of a body remains same before and after the collision.

As stated in law the sum will be zero,

So,

$P_1 = P_2$

$m_1v_1 = m_2v_2$

Hence, both parts will have numerically equal momentum.

305. A force of 10 N acts on a body of mass 20 kg for 10 s. Change in its momentum is

(a) 5 kg m/s (b) 100 kg m/s
(c) 200 kg m/s (d) 1000 kg m/s

Manipal UGET-2011

Ans. (b) : Given that,

$F = 10N, m = 20 \text{ kg}$

$t = 10 \text{ s}$

From Newton's second law of motion

$F = ma$

$10 = 20 \times a$

$a = 0.5 m/s^2$

Now, from equation of motion

$v = u + at$

Here $u = 0$

Then,

$v = 0 + 0.5 \times 10$

$= 5 m/s$

Now, change in momentum;

$$F = \frac{\Delta P}{\Delta t}$$

$$\Delta P = F \times t$$

$$= 10N \times (10s) = 100 \text{ kg m/s}$$

306. A particle moves in the xy-plane under the action of a force F such that the components of its linear momentum p at any time t are $p_x = 2 \cos t$, $p_y = 2 \sin t$. The angle between F and p at time t is

(a) 90° (b) 0°
(c) 180° (d) 30°

Manipal UGET-2011

Ans. (a) : Given that,

$p_x = 2\cos t,\ p_y = 2\sin t$

$\therefore \quad \vec{P} = 2\cos t\,\hat{i} + 2\sin t\,\hat{j}$

$$\vec{F} = \frac{\overrightarrow{dp}}{dt} = -2\sin t\,\hat{i} + 2\cos t\,\hat{j}$$

$$\vec{F}.\vec{p} = \left(-2\sin t\,\hat{i} + 2\cos t\,\hat{j}\right)\cdot\left(2\cos t\,\hat{i} + 2\sin t\,\hat{j}\right)$$

$$\vec{F}.\vec{P} = 0$$

$\therefore \quad \theta = 90°$

Since the dot product of two non zero vectors is zero.

Therefore, angle between $\vec{F}$ and $\vec{P}$ is 90°.

307. Assertion: A helicopter must necessarily have two propellers.

Reason: Two propellers are provided in helicopter in order to conserve linear momentum.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2010

Ans. (c) : A helicopter must necessarily have two propellers the helicopter itself would have turned in the opposite direction of the propeller, which is due to the conservation of angular momentum.

The helicopter has two propellers to balance the angular momentum but not linear momentum.

308. A particle of mass m is moving with a uniform velocity v_1. It is given an impulse such that its velocity becomes v_2. The impulse is equal to

(a) $m\left[|v_2| - |v_1|\right]$ (b) $\frac{1}{2}m\left(v_2^2 - v_1^2\right)$
(c) $m(v_1 + v_2)$ (d) $m(v_2 - v_1)$

AIPMT- 1990

Ans. (d) : Impulse is a vector quantity and is equal to change in momentum of the body.

$\because$ Impulse $= \Delta P = P_f - P_i$

Impulse $= m(v_2 - v_1)$

309. A ball of mass 150 g moving with an acceleration 20 m/s^2 is hit by a force, which acts on it for 0.1 s. The impulsive force is

(a) 0.5 N-s (b) 0.1 N-s
(c) 0.3 N-s (d) 1.2 N-s

AIPMT- 1996

Ans. (c) : Given that,

mass of ball = 150 g,

$a = 20 m/s^2$

$t = 0.1s$

We know,

$f = ma = 150 \times 10^{-3} \times 20 = 3N$

Impulse $= f \times t$

$\therefore$ Impulse $= 3 \times 0.1 = 0.3$ N–s

310. An object of mass 3 kg is at rest. If a force $F = (6t^2\hat{i} + 4t\hat{j})$ N is applied on the object, then the velocity of the object at t = 3 s is

(a) $18\hat{i} + 3\hat{j}$ (b) $18\hat{i} + 6\hat{j}$
(c) $3\hat{i} + 18\hat{j}$ (d) $18\hat{i} + 4\hat{j}$

AIPMT- 2002

Ans. (b) : Given, mass = 3 kg, t = 3s

$F = (6t^2\hat{i} + 4t\hat{j})$ N

we know that

$\vec{F} = m\vec{a}$

@apna_pdf

$$\vec{F} = m\frac{d\vec{v}}{dt}$$

$$d\vec{v} = \frac{\vec{F}}{m}dt$$

$$d\vec{v} = \frac{6t^2\hat{i} + 4t\hat{j}}{3}$$

$$\int_0^{\vec{v}} d\vec{v} = \frac{1}{3}\int_0^3 \left(6t^2\hat{i} + 4t\hat{j}\right)dt$$

$$\vec{v} = \frac{1}{3}\left[\frac{6t^3}{3}.\hat{i} + \frac{4t^2}{2}.\hat{j}\right]_0^3$$

$$= \frac{1}{3}\left[2\times(3)^3.\hat{i} + 2\times(3)^2.\hat{j}\right]$$

$$\therefore \vec{v} = 18\hat{i} + 6\hat{j}$$

311. A player takes 0.1 s in catching ball of mass 150 g moving with velocity of 20 m/s. The force imparted by the ball in the hands of the player is

(a) 0.3 N	(b) 3 N
(c) 30 N	(d) 300 N

AIPMT- 2001

Ans. (c) : Given that,

Mass = 150g

u = 20m/s

$\Delta t = 0.1s$

F = Rate of change of momentum

$$F = \frac{m(v-u)}{t}$$

$$F = \frac{0.15(0-20)}{0.1}$$

$F = -30N$

The magnitude of the force is 30N and the direction will be opposite to the direction of the previous motion of the ball. Hence, the force exerted by the ball on the hand of the player is 30 N.

312. 1 kg body explodes into three fragments. The ratio of their masses is 1: 1: 3. The fragments of same mass move perpendicular to each other with speeds 30 m/s, while the heavier part remains in the initial direction. The speed of heavier part is

(a) $\frac{10}{\sqrt{2}}$ m/s	(b) $10\sqrt{2}$ m/s
(c) $20\sqrt{2}$ m/s	(d) $30\sqrt{2}$ m/s

AIPMT- 2001

Ans. (b) : Let mass of three fragments be m_1, m_2 and m_3

$$\therefore m_1 = \frac{1}{5} = 0.2kg$$

$$m_2 = \frac{1}{5} = 0.2kg$$

$$m_3 = \frac{3}{5} = 0.6kg$$

We know,

Momentum (p) = mv

$\therefore$ $p_1 = m_1v = 0.2 \times 30 = 6$ kgm/s

$p_2 = m_2v = 0.2\times 30 = 6$ kgm/s

$\therefore$ p_3 will in opposite direction of resultant of A and p_2 So, that the momentum of the system become zero,

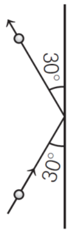
$$\therefore p_3 = \sqrt{p_1^2 + p_2^2}$$

$$p_3 = \sqrt{6^2 + 6^2} = 6\sqrt{2}\,kg\,m/s$$

Thus speed of third fragments

$$v_3 = \frac{p_3}{m_3} = \frac{6\sqrt{2}}{0.6} = 10\sqrt{2}\,m/s$$

313. A 0.5 kg ball moving with a speed of 12 m/s strikes a hard wall at an angle of 30° with the wall. It is reflected with the same speed and at the same angle. If the ball is in contact with the wall for 0.25 s, the average force acting on the wall is



(a) 48 N	(b) 24 N
(c) 12 N	(d) 96 N

AIPMT- 2006

Ans. (b) Given that,

m = 3kg

v = 12 m/s

θ = 30º

t = 0.25sec.

$\therefore$ Angle is given from vertical component

Hence,

$$F = \frac{2mv\sin\theta}{t} = \frac{2\times3\times12\times\sin30^\circ}{0.25}$$

F = 24 N

314. Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v along x-axis. After collision, B has a velocity $\frac{v}{2}$ in a direction perpendicular to the original direction. The mass A moves after collision in the direction

(a) same as that of B

(b) opposite to that of B

(c) $\theta = \tan^{-1}\left(-\frac{1}{2}\right)$ to the x-axis

(d) $\theta = \tan^{-1}\left(\frac{-1}{2}\right)$ to the x-axis

AIPMT- 2012

@apna_pdf

Ans. (c) : As per given question, apply law of conservation of momentum along x-axis,

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

$$m_1 \times 0 + m_2 v = m_1 v_x + m_2 \times 0$$

$$\therefore \quad v_x = \frac{m_2 v}{m_1} \quad \text{....(i)}$$

Similarly along y-axis,

$$m_1 \times 0 + m_2 \times 0 = m_1 v_y + m_2 \left(\frac{v}{2}\right)$$

$$\therefore \quad v_y = -\frac{m_2 v}{2m_1} \quad \text{.... (ii)}$$

$$\therefore \quad \tan\theta = \frac{v_y}{v_x} = \frac{-\frac{m_2 v}{2m_1}}{\frac{m_2 v}{m_1}} = -\frac{1}{2}$$

$$\therefore \ \theta = \tan^{-1}\left(-\frac{1}{2}\right) \text{ along x-axis}$$

315. A man of 50 kg mass is standing in a gravity free space at a height of 10 m above the floor. He throws a stone of 0.5 kg mass downwards with a speed 2ms^{-1}. When the stone reaches the floor, the distance of the man above the floor will be

(a) 9.9 m (b) 10.1 m

(c) 10 m (d) 20 m

AIPMT- 2010

Ans. (b) : Given,

Mass of man = 50kg

Mass of stone = 0.5 kg, h = 10 m

Apply conservation of momentum

$$p_f = p_i$$

$$m_{man} \times v - m_{stone} \times v_{stone} = 0$$

$$50v - 0.5 \times 2 = 0$$

$$v = 0.02 \text{ m/s}$$

Time taken for stone to reach the floor,

$$t = \frac{10}{2} = 5\text{sec}$$

Distance travelled by man in 5 s = 0.02 × 5

= 0.1 m.

Hence, distance of the man above the floor (S)

$$S = 10 + 0.1$$

$$= 10.1\text{m.}$$

316. A bullet of mass 10 g moving horizontal with a velocity of 400 m/s strikes a wood block of mass 2 kg which is suspended by light inextensible string of length 5m. As result, the centre of gravity of the block found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges of horizontally from the block will be

(a) 100 m/s (b) 80 m/s

(c) 120 m/s (d) 160 m/s

NEET- 2016

Ans. (c) : Given that,

Mass of bullet (m_1) = 10g = 0.01 kg

u = 400 m/s

mass of wooden block (m_2) = 2 kg

length = 5m

After collision,

velocity of bullet = v_1

velocity of block = v_2

block rises height = 10 cm = 0.1m

According to the conservation of energy

P.E at the maximum height = KE at the bottom of block

$$m_2 gh = \frac{1}{2} m_2 v_2^2$$

$$v_2 = \sqrt{2gh} = \sqrt{2 \times 9.8 \times .1}$$

$$v_2 = 1.4\text{m/s}$$

According to the conservation of momentum–

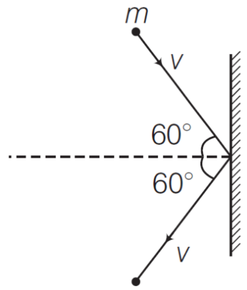
$$m_1.u_1 = m_2.v_2 + m_1.v_1$$

$$v_1 = \frac{m_1 u_1 - m_2 v_2}{m_1}$$

$$v_1 = \frac{0.01 \times 400 - 2 \times 1.4}{0.01}$$

$$v_1 = 120 \text{ m/s}$$

317. A rigid ball of mass m strikes a rigid wall at 60° and gets reflected without loss of speed as shown in the figure. The value of impulse imparted by the wall on the ball will be



(a) mv (b) 2mv

(c) mv/2 (d) mv/3

AIPMT- 2000

NEET- 2016

Ans. (a) : Given, mass of ball = m, angle (θ) = 60°

We know that,

$$\text{Impulse } (I) = F.\Delta t$$

$$I = \frac{\Delta p}{\Delta t}.\Delta t$$

$$I = \Delta p$$

Hence,

Change in momentum (Δp) = 2mv cosθ

$$\therefore \quad I = 2mv \cos 60^\circ$$

$$I = 2mv\frac{1}{2}$$

$$I = m.v$$

Hence, impulse imparted by the wall on the ball is mv.

@apna_pdf

318. Two trolleys of masses m and 3m are connected by a spring. The spring is compressed and released the trolleys move off in opposite directions and come to rest after travelling distance s_1 and s_2 respectively. Assuming coefficient of friction is same for both the ratio of s_1 to s_2 is

(a) 1 : 9 (b) 1 : 3
(c) 3 : 1 (d) 9 : 1

EAMCET-1995

Ans. (d) : Given, $m_1 = m$, $m_2 = 3m$

According to law of conservation of momentum-

$$m_1v_1 = m_2v_2$$
$$mv_1 = 3mv_2$$

or $$\frac{v_1}{v_2} = \frac{3}{1} \quad .....(i)$$

When mass m_1 and m_2 compressed they possesses some potential energy which converted into kinetic energy.

According to work– energy principle-

$$\frac{1}{2}mv^2 = F \times s$$
$$\frac{1}{2}m_1v_1^2 = \mu m_1 g s_1 \quad .....(ii)$$
$$\frac{1}{2}m_2v_2^2 = \mu m_2 g s_2 \quad .....(iii)$$

Dividing equation (ii) by equation (iii), we get-

$$\frac{s_1}{s_2} = \frac{v_1^2}{v_2^2} = \left(\frac{3}{1}\right)^2 = \frac{9}{1}$$

$\therefore$ $s_1 : s_2 = 9 : 1$

319. A solid wooden block resting on a frictionless surface is hit by a bullet. The bullet gets embedded. During this process

(a) only kinetic energy is conserved
(b) only momentum is conserved
(c) both momentum and kinetic energy are conserved
(d) neither momentum nor kinetic energy is conserved

EAMCET-1996

Ans. (b) : When bullet hit wooden block then energy (kinetic energy) is lost and therefore it is not conserved.
When bullet hit wooden block it is perfectly inelastic collision in which only momentum is conserved.

320. A car of mass 400 kg and travelling at 72 kmh^{-1} crashes into a truck of mass 4000 kg and travelling at 9 kmh^{-1}, in the same direction. The car bounces back at a speed of 18 kmh^{-1}. The speed of the truck after the impact is

(a) 9 kmh^{-1} (b) 18 kmh^{-1}
(c) 27 kmh^{-1} (d) 36 kmh^{-1}

EAMCET-1998

Ans. (b): Given,

$$m_1 = 400kg, m_2 = 4000\ kg$$
$$u_1 = 72\ kmh^{-1} = 72 \times \frac{5}{18}\ ms^{-1} = 20ms^{-1}$$
$$u_2 = 9\ kmh^{-1} = 9 \times \frac{5}{18} = 2.5\,ms^{-1}$$
$$v_1 = -18\ kmh^{-1} = 18 \times \frac{5}{18} = -5ms^{-1}$$

According to law of conservation of linear momentum,
We get,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$400 \times 20 + 4000 \times 2.5 = 400 \times (-5) + 4000 \times v_2$$
$$400\,(20 + 10 \times 2.5) = 400(-5 + 10 \times v_2)$$
$$20 + 25 = -5 + 10\,v_2$$
$$45 + 5 = 10\,v_2$$
$$v_2 = \frac{50}{10} = 5\ m/s$$
$$v_2 = 5 \times \frac{18}{5} = 18\ kmh^{-1}$$

321. A Rifle of 20 kg mass can fire 4 bullet/s. The mass of each bullet is 35 × 10^{-3} kg and its final velocity is 400 ms^{-1}. Then, what force must be applied on the rifle so that it does not move backward while firing the bullets?

(a) 80 N (b) 28 N
(c) –112 N (d) –56 N

EAMCET-2007

Ans. (d): Given,

Mass of rifle (M) = 20kg
Mass of bullet (m) = 35×10^{-3}
$v = 400$ m/s.

Apply law of conservation of momentum–

$$MV + 4mv = 0$$
$$V = \frac{-4mv}{M}$$
$$V = \frac{-4 \times 35 \times 10^{-3} \times 400}{20} = -2.8m/s$$

Where,
V is recoil velocity of rifle.
Force applied on the rifle is–

$$F = \frac{P}{t} = \frac{-M.V}{t} = \frac{20 \times (-2.8)}{1} = -56N$$

Here, negative sign shows opposite direction.

322. A Jet engine works on the principal of conservation of:

(a) linear momentum
(b) angular momentum
(c) energy
(d) mass

NDA (I) 2011

Ans. : (a) A Jet engine work on the principle of conservation of linear momentum.
The conservation of linear momentum states that the body in motion will retain its total momentum unless an extremely force is applied to it.
Initial momentum = Final momentum

@apna_pdf

323. An object is undergoing a non accelerated motion. Its rate of change in momentum is

(a) a non-zero constant
(b) zero
(c) not a constant
(d) None of the above

NDA (I) 2013

Ans. (b) : An object is undergoing a non- accelerated motion, $a = 0$

or $\frac{dv}{dt} = 0$ …(i)

We know that,

Rate of change of momentum,

$$\frac{dp}{dt} = m.\frac{dv}{dt} \qquad [\because p = mv]$$

$$\frac{dp}{dt} = m.0 \qquad \text{[From equation (i)]}$$

$$\frac{dp}{dt} = 0$$

324. Two bodies A and B are moving with equal velocities. The mass of B is double that of A. In this context, which one of the following statements is correct?

(a) Momentum of B will be double that of A.
(b) Momentum of A will be double that of B.
(c) Momentum of B will be four times that of A.
(d) Momentum of both A and B will be equal.

NDA (I) 2016

Ans. : (a) Given ,

Velocity of body A and B is

$v_A = v_B = v$

And mass,

$m_B = 2m_A$

We known that,

Momentum (p) = m.v

Momentum of the Body A is–

$p_A = m_Av$ (i)

Momentum of Body B is–

$p_B = 2m_Av$ (ii)

From equation (i) and (ii)–

$$\frac{p_A}{p_B} = \frac{m_Av}{2m_Av}$$

$p_B = 2p_A$

Hence, momentum of B will be double that of A.

325. A ball hits a vertical wall horizontally at $10 ms^{-1}$ and bounces back at $10 ms^{-1}$, then

(a) There is no acceleration because $10 ms^{-1} = 0$
(b) There may be an acceleration because it initial direction is horizontal
(c) There is an acceleration because there is a momentum change
(d) Even though there is no charge in momentum there is a change in direction. Hence, it has an acceleration

UP CPMT-2009

Ans. (c) : The change in momentum = 2mv, because the ball bounces back with the same speed.

Also since we know that force = rate of change of momentum

So, force will act on the ball.

326. A bomb of mass 3.0 kg explodes in air into two pieces of masses 2.0 kg and 1.0 kg. The smaller mass goes at a speed of 80 m/s. The total energy imparted to the two fragments is

(a) 1.07 kJ
(b) 2.14 kJ
(c) 2.4 kJ
(d) 4.8 kJ

UP CPMT-2007

Ans. (d) : Given –

mass of the bomb, $M = 3$ kg, $u = 0$

$m_1 = 2kg$

$m_2 = 1kg$

$v_1 = 80$ m/s, $v_2 = ?$

According to conservation of momentum –

$Mu = m_1v_1 + m_2v_2$

$3\times0 = 1\times80+2\times v_2$

$$v_2 = \frac{-80}{2} = -40\,m/s$$

Total kinetic energy,

$$KE = \left(\frac{1}{2}\right)m_1v_1^2 + \left(\frac{1}{2}\right)m_2v_2^2$$

$$= \left(\frac{1}{2}\right)\times1\times(80)^2 + \left(\frac{1}{2}\right)\times2\times(-40)^2$$

$= 3200 + 1600$

$= 4800J$

$K.E = 4.8\,kJ$

327. An atom bomb weighing 1 kg explodes releasing 9×10^{13}J of energy. What percentage of mass is converted into energy?

(a) 0.1%
(b) 1%
(c) 2%
(d) 10%

UP CPMT-2013

Ans. (a) : Given,

$E = 9 \times 10^{13}$ J

$c = 3 \times 10^8\ ms^{-2}$

We know that,

$E = mc^2$

$9 \times 10^{13} = m(3 \times 10^8)^2$

$$m = \frac{9\times10^{13}}{\left(3\times10^8\right)^2} = \frac{9\times10^{13}}{9\times10^{16}}$$

$m = 1 \times 10^{-3}$ kg

$$\frac{\Delta m}{m}\times100 = 10^{-3} \times 100 = 0.1\%$$

328. N bullets each of mass m kg are fired with a velocity v ms^{-1} at the rate of n bullets per second upon a wall. The reaction offered by the wall to the bullets is given by

@apna_pdf

(a) nmv
(b) $\frac{Nmv}{n}$
(c) $\frac{nNm}{v}$
(d) $\frac{nNv}{m}$

UP CPMT-2011

Ans. (a) : If mass of each bullet = m kg

Then, total mass of bullets = Nm kg

$$\text{Time } t = \frac{N}{n} = \frac{\text{No. of bullet}}{\text{No. of bullet / sec}}$$

Momentum of the bullets striking the wall = Nmv

$$\text{Rate of change of momentum} = \frac{N\,mv}{t} = \frac{Nmvn}{N}$$

$$= nmv$$

329. A Bomb of 12 kg explodes into two pieces of masses 4 kg and 8 kg. The velocity of 8 kg mass is 6 m/s. The kinetic energy of the other mass is

(a) 348 J
(b) 332 J
(c) 324 J
(d) 288 J

UP CPMT-2010

Ans. (d) : Given –

Mass of Bomb, M = 12kg

After explosion, first part of mass = m_1

second part of mass = m_2

As, the initial momentum of the Bomb was zero, therefore after explosion the two parts should posses numerically equal momentum i.e.

$$m_1v_1 = m_2v_2$$

$$4v_1 = 8 \times 6$$

$$v_1 = 12 \text{ m/s}$$

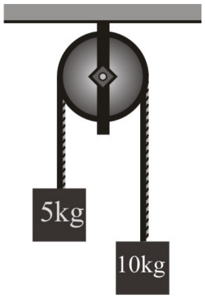
Kinetic energy of the other mass,

$$(KE)_1 = \frac{1}{2}m_1v_1^2$$

$$= \frac{1}{2} \times 4 \times (12)^2$$

$$= 288\,J$$

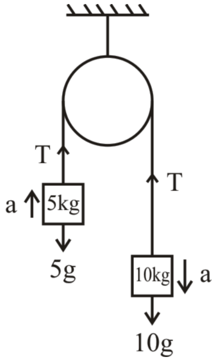
330. Two masses of 5 kg and 10 kg are connected to a pulley as shown. What will be the acceleration of the system? (g = acceleration due to gravity)



(a) g
(b) g/2
(c) g/3
(d) g/4

UP CPMT-2010

Ans. (c) :



For 5 kg mass–

$$T - 5g = 5a \qquad \text{.....(i)}$$

For 10kg mass–

$$10g - T = 10a \qquad \text{.....(ii)}$$

From equation (i) and (ii)

$$5g = 15a$$

$$a = \frac{g}{3}$$

331. A ball of mass m elastically collides with a wall with velocity v, then change in its momentum is equal to

(a) 2 m
(b) 2 mv
(c) 8 mv
(d) zero

UP CPMT-2005

Ans. (b) : A ball of mass = m

Moving with velocity = v

Now,

Momentum of ball will be, $p_{initial}$ = mv

Final momentum of ball, p_{final} = –mv

Then, change in momentum will be -

$$\Delta p = p_{(initial)} - p_{(final)}$$

$$= mv - (-mv)$$

$$= 2\,mv$$

332. Two bodies of masses 'm' and '2m' have equal kinetic energies. The ratio of their linear momentum is

(a) 1
(b) $\frac{1}{2}$
(c) $\frac{1}{\sqrt{2}}$
(d) 2

UP CPMT-2005

Ans. (c) : Kinetic energy of both bodies,

$$\frac{1}{2}m_1v_1^2 = \frac{1}{2}m_2v_2^2$$

Now,

$$\frac{v_1^2}{v_2^2} = \frac{m_2}{m_1}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}} \qquad \text{.....(i)}$$

@apna_pdf

Multiply and divide by m_1 & m_2 with equation (i)

$$\frac{m_1v_1}{m_2v_2}=\sqrt{\frac{m_2}{m_1}}\times\frac{m_1}{m_2}$$

$$\frac{P_1}{P_2}=\sqrt{\frac{m_2}{m_1}}\times\sqrt{\frac{m_1}{m_2}}\times\sqrt{\frac{m_1}{m_2}}$$

$$\frac{P_1}{P_2}=\sqrt{\frac{m_1}{m_2}}$$

$$=\sqrt{\frac{m}{2m}}$$

$$\frac{P_1}{P_2}=\frac{1}{\sqrt{2}}$$

333. An object A of mass 2 kg is moving with a velocity of 3 m s^{-1} and collides head on with an object B of mass 1 kg moving in the opposite directions with a velocity of 4 m s^{-1}. After collision both objects coalesce so that they move with a common velocity v equal

(a) $\frac{2}{3}\text{m s}^{-1}$ (b) 1 m s^{-1}

(c) 2 m s^{-1} (d) 3 m s^{-1}

SRM JEE - 2012

Ans. (a) : Given that,

$m_A = 2\text{kg}$, $v_A = 3$ m/s,

$m_B = 1$ kg, $v_B = 4$ m/s

Let common velocity = v

Applying the conservation of momentum –

$$m_Av_A - m_Bv_B = (m_A + m_B)v$$

[∵ A and B have opposite velocities]

$$2(3)-1(4)=(2+1)v$$

$$6-4=3v$$

$$v=\frac{2}{3}\text{m/s}$$

334. The distance covered by a body of mass 5 g having linear momentum 0.3 kg m/s in 5s is:

(a) 300 m (b) 30 m

(c) 3 m (d) 0.3 m

SRM JEE-2014

Ans. (a) : Given,

m = 5g

Linear momentum, p = 0.3 kg-m/sec

t = 5 sec

Distance (d) = ?

We know that,

p = mv

$$v=\frac{p}{m}\Rightarrow\frac{0.3\times1000}{5}$$

v = 60 m/sec

$$\because \text{velocity, } v=\frac{d}{t}$$

So, d = vt

d = 60 × 5

d = 300 m

335. The moment of linear momentum is

(a) angular acceleration

(b) angular momentum

(c) rotational kinetic energy

(d) moment of inertia

MP PET -2013

Ans. (b) : The moment of linear momentum is called angular momentum.

Angular momentum, $L=\vec{r}\times\vec{p}$

Where 'p' is linear momentum.

Note-Angular momentum is the property of a body in rotational motion.

336. Internal forces can change:

(a) Linear momentum but not the kinetic energy

(b) Kinetic energy but not the linear momentum

(c) Linear momentum as well as kinetic energy

(d) Neither linear momentum nor kinetic energy

MP PET-2012

Ans. (b) : According to the law of conservation of momentum the overall momentum of the system remains unchanged. Internal force can change only have an effect on the mechanical energy like kinetic energy and potential energy.

337. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 ms^{-1}. The kinetic energy of the other mass is

(a) 256 J (b) 486 J

(c) 524 J (d) 324 J

JIPMER- 2007

Ans. (b) : Given that,

m_1= 18kg, m_2=12kg

$u_1=6ms^{-1}$, u_2= ?

The linear momentum of exploding part will remain conserved.

Applying conservation of linear momentum,

$m_1u_1 = m_2u_2$

∴ $18\times6 = 12\times u_2$

$$u_2=\frac{18\times6}{12}=9ms^{-1}$$

Thus, Kinetic energy of 12 kg mass,

$$K_2=\frac{1}{2}m_2u_2^2$$

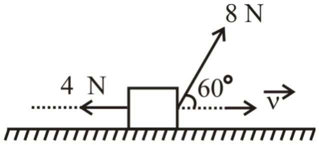
$$=\frac{1}{2}\times12\times(9)^2$$

$= 6 \times 81$

$= 486$ J

338. Two forces of magnitudes 4 N and 8 N are acting on a box, when the box moves rightward across a frictionless horizontal support. The speed of the box at time t is 1m s^{-1}. The change in kinetic energy of the box is

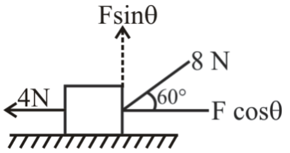
@apna_pdf



(a) Zero (b) 80 J
(c) 8 J (d) 4 J

Assam CEE-2016

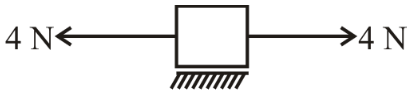
Ans. (a) :



From above figure-

$$F\cos 60° = 8 \times \frac{1}{2} = 4\text{ N}$$

Now,



$$F_{net} = 0$$

Block is rest.

Hence, ΔK.E. = 0

339. A bullet of mass 20 g moving with a speed of 100 m s^{-1} enters a heavy wooden block and stops after a distance of 50 cm. The average resistive force exerted by the block on the bullet is

(a) 100 N (b) 10000 N
(c) 200 N (d) 500 N

Assam CEE-2016

Ans. (c) : Given that,

$$u = 100\text{ ms}^{-1},\ v = 0$$

$$m = 20g = \frac{20}{1000}\text{kg} = 0.02\text{kg}$$

$$s = 50\text{cm} = 0.5\text{ m}$$

Using the third equation of motion,

$$v^2 - u^2 = 2as$$

$$\therefore \quad (0)^2 - (100)^2 = 2a \times 0.5$$

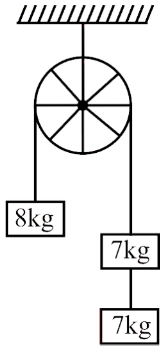
$$a = \frac{(100)^2}{2 \times 0.5} = -10000\text{ ms}^{-2}$$

Negative sign shows the retardation.

∴ The average resistive force exerted by block on the bullet is

$$F = m \times a$$
$$= 0.02 \times 10{,}000$$
$$= 200\text{ N}$$

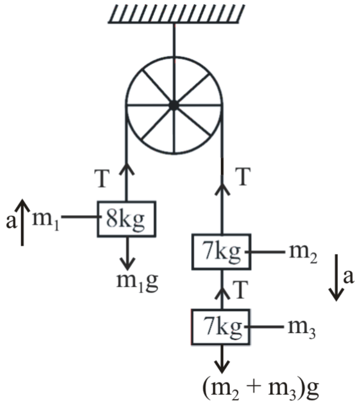
340. A light string passes over a frictionless pulley. To one of its ends a mass of 8 kg is attached. To its other end two masses of 7 kg each are attached. The acceleration of the system will be



(a) 10.2 g (b) 5.10 g
(c) 20.36 g (d) 0.27 g

JIPMER-2016

Ans. (d) :



From the free body diagram,

$$m_1 a = T - m_1 g$$
$$8a = T - 8g$$
$$T = 8a + 8g \qquad \text{...(i)}$$

After combining the mass of m_2 and m_3,

$$m_2 + m_3 = 7 + 7 = 14\text{ kg}$$

Now, from the free body diagram,

$$(m_2 + m_3)a = (m_2 + m_3)g - T$$
$$14a = 14\text{ g} - T \qquad \text{...(ii)}$$

From the equation (i) putting the value of T in equation (ii)

Now,
$$14a = 14g - (8a + 8g)$$
$$14a + 8a = 14g - 8g$$
$$22a = 6g$$
$$a = \frac{6}{22}g$$
$$a = 0.27g$$

341. A ball A of mass m moving along positive x-direction with kinetic energy K and momentum p undergoes elastic head on collision with a stationary ball B of mass M after collision the ball A moves along negative x-direction with kinetic energy $\frac{K}{9}$, final momentum of B is

(a) p (b) $\frac{p}{3}$

@apna_pdf

(c) $\frac{4p}{3}$ (d) 4p

AP EAMCET -2012

Ans. (c) : Given,
Mass of ball 'A' $(m_1) = m$
Kinetic energy of ball 'A' before collision, $K_1 = K$
Mass of ball 'B' $(m_2) = M$
Kinetic energy of ball 'A' after collision, $K_1 = \frac{K}{9}$
Let the magnitudes of final moments of A and B be p_1, p_2
We know that,

$$K = \frac{p^2}{2m}$$
$$p^2 = 2Km$$
$$p \propto \sqrt{K}$$

Thus, $p = p_2 - p_1$

$$p_2 = p_1 + p$$
$$p_2 = \sqrt{K_1} + p$$
$$p_2 = \sqrt{\frac{K}{9}} + p \qquad \left(\because K_1 = \frac{K}{9}, \text{after collision}\right)$$
$$p_2 = \frac{\sqrt{K}}{3} + p$$
$$p_2 = \frac{p}{3} + p = \frac{4}{3}p$$

342. A man fires a bullet of mass 200 g at a speed of 5m/s. The gun is of one kg mass. By what velocity the gun rebounds backward?
(a) 1 m/s (b) 0.01 m/s
(c) 0.1 m/s (d) 10 m/s

AMU-2015

Ans. (a) : Mass of bullet $(m_b) = 200$ g $= 0.2$ kg
Speed of bullet $(v_b) = 5$ m/s
Mass of gun $(m_g) = 1$ kg
Velocity of gun $(v_g) = ?$
Before firing, total momentum is as zero. After firing, total momentum is $m_1v_1 + m_2v_2$ from the law of conservation of momentum,

$$m_bv_b + m_gv_g = 0$$
$$v_g = \frac{-m_bv_b}{m_g} = -0.2 \times \frac{5}{1} = -1 \text{ m/sec}$$

$v_g = 1$m/sec (Rebound backward)

343. A shell of mass 200 g is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 m/s, calculate the recoil speed of the gun.
(a) 16 cm/s (b) 8 cm/s
(c) 4 cm/s (d) 16 m/s

AMU-2012

Ans. (a) : Given data,
Mass of the gun $(m_g) = 100$ Kg
Mass of the shell $(m_s) = 200$ g $= 200 \times 10^{-3}$ Kg
Muzzle speed of the shell $(v_s) = 80$ m/sec
Recoil speed of the gun $(v_g) = ?$
According to the principle of conservation of linear momentum,

$$m_gv_g + m_sv_s = 0$$
$$v_g = -\frac{m_sv_s}{m_g}$$
$$= -\frac{(200 \times 10^{-3}\text{kg})(80\text{ms}^{-1})}{100\text{kg}}$$
$$v_g = -16 \times 10^{-2} \text{ ms}^{-1}$$
$$v_g = -16 \text{ cm s}^{-1}$$

Note:– Negative sign indicate that the recoil speed of the gun will be in a direction opposite to that of the shell.

344. A stationary body of mass 3kg explodes into three equal pieces. Two of the pieces fly off at right angles to each other, one with a velocity 2 $\hat{i}$ m/s and the other with a velocity 3 $\hat{j}$ m/s if the explosion takes place in 10^{-5}s, the average force acting on the third piece in Newton is ...
(a) $(2\hat{i}+3\hat{j})\times10^{-5}$ (b) $-(2\hat{i}+3\hat{j})\times10^{5}$
(c) $(3\hat{i}-2\hat{j})\times10^{5}$ (d) $(2\hat{i}-3\hat{j})\times10^{-5}$

AP EAMCET(Medical)-2003

Ans. (b) : Since, the body explodes into three equal parts. Therefore,

$$m_1 = m_2 = m_3 = \frac{m}{3} = \frac{3\text{kg}}{3} = 1 \text{ kg}$$

Let the velocity of the third part be $\vec{v}$. According to the principle of conservation of linear momentum,
Momentum of system before explosion = Momentum of system after explosion
i.e. $mv = m_1v_1 + m_2v_2 + m_3v_3$

$$3 \times 0 = 1\times2\hat{i} + 1\times3\hat{j} + 1\times\vec{v}$$
$$\vec{v} = -(2\hat{i}+3\hat{j}) \text{ m/s}$$

∴ Average force acting on the third particle is

$$\vec{F} = \frac{m\vec{v}}{t} = \frac{-1\times(2\hat{i}+3\hat{j})}{10^{-5}}$$
$$\vec{F} = -(2\hat{i}+3\hat{j})\times10^{5}\text{ N}$$

345. A gun of mass of 10kg fires 4 bullets per second. The mass of each bullet is 20g and the velocity of the bullet when it leaves the gun is 300ms^{-1} . The force required to hold the gun while firing is:
(a) 6N (b) 8N
(c) 24N (d) 240N

AP EAMCET(Medical)-2000

@apna_pdf

Ans. (c) : Given,

Mass of each bullet (m) = 20g = 20×10^{-3}kg

No. of bullet (n) = 4

Velocity (v) = 300 ms^{-1}

Time (t) = 1 sec

Force = ?

According to Newton's second law, the rate of change in momentum (p) of an object is equal to the force (F) applied.

$$F = \frac{dp}{dt}$$

$$F = \frac{d(mv)}{dt} \qquad [\because p = mv]$$

$$F_{single} = m\frac{dv}{dt}$$

$$\frac{dv}{dt}\times m = ma \qquad \left[\because a = \frac{dv}{dt}\right]$$

$$F_{single} = \frac{300}{1}\times 20\times10^{-3} = 6\,N$$

So, $F_{Total} = n\times F_{single}$

$F_{Total} = 4 \times 6 = 24$ N

346. Nucleus of mass number A, originally at rest, emits the α-particle with speed v. The daughter nucleus recoils with a speed of

(a) 2v /(A+4)
(b) 4v/(A+4)
(c) 4v/(A– 4)
(d) 2v/(A– 4)

Manipal UGET-2014

Ans. (c) : Mass number = Mass of protons + Mass of neutrons

Thus mass number of α-particles = 4

Applying conservation of linear momentum.

$$A \times 0 = (A-4)v' - 4v$$

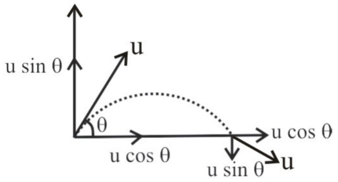
$$v' = \frac{4v}{A-4}$$

347. A ball is thrown up at an angle with the horizontal. Then the total change of momentum by the instant it returns to ground is–

(a) Acceleration due to gravity × total time of flight
(b) Weight of the ball × half the time of flight
(c) Weight of the ball × total time of flight
(d) Weight of the ball × horizontal range

BCECE-2008

Ans. (c) :



Initial momentum = P_i

Final momentum = P_f

Change in momentum-

$$|\Delta P| = |P_f - P_i|$$

$$= |m(-u\sin\theta) - m(u\sin\theta)|$$

$$= |-2mu\sin\theta|$$

$$|\Delta P| = 2mu\sin\theta \qquad .....(i)$$

We know that,

$$v = u + at$$

$$0 = u\sin\theta - gt$$

$$t = \frac{u\sin\theta}{g}$$

$$\therefore T_f = 2t = \frac{2u\sin\theta}{g} \quad \text{Where, } T_f = \text{Total time of flight}$$

∴ Multiply and divide equation (i), by g.

$$|\Delta P| = 2mu\sin\theta \times \frac{g}{g}$$

$$= mg\times\frac{2u\sin\theta}{g}$$

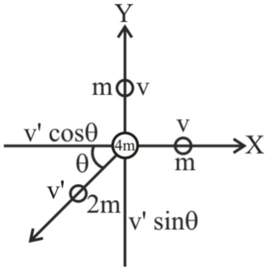
|ΔP| = Weight of Ball × Total Time of flight

348. A particle of mass 4m which is at rest explodes into three fragments. Two of the fragments each of mass m are found to move with a speed 'v' each in mutually perpendicular directions. The total energy released in this process:

(a) 0
(b) $\frac{3}{2}mv^2$
(c) $\frac{1}{2}mv^2$
(d) $2\,mv^2$

MP PET-2012

Ans. (b) :



Along X-axis

$$2mv'\cos\theta = mv$$

$$v' = \frac{v}{2\cos\theta} \qquad ... (i)$$

Along Y-axis

$$2mv'\sin\theta = mv$$

$$v' = \frac{v}{2\sin\theta} \qquad .... (ii)$$

From equation (i) and (ii), we get –

$$\frac{v}{2\cos\theta} = \frac{v}{2\sin\theta}$$

$$\tan\theta = 1 = \tan 45°$$

$$\theta = 45°$$

So, $v' = \frac{v}{\cos\theta} = \frac{v}{2\cos45°} \Rightarrow v' = \frac{v}{\sqrt{2}}$

@apna_pdf

Total energy = Sum of kinetic energy of all the particle

$$\text{T.E} = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)\left(\frac{v}{\sqrt{2}}\right)^2$$

$$\text{T.E} = mv^2 + \frac{1}{2}2m \cdot \frac{v^2}{2}$$

$$\text{T.E} = mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$$

349. A force of 100 N acts on a body of mass 2 kg for 10 s. The change in momentum of the body is:

(a) 100 Ns
(b) 250 Ns
(c) 500 Ns
(d) 1000 Ns

AP EAMCET(Medical)-1999

Ans. (d) : Given data,

Mass of body (m) = 2kg

Applied force (F) = 100 N

Time (t) = 10 sec

By Newton's second law,

$F = m.a$

$$F = m \times \left(\frac{v-u}{t}\right)$$

$$100 = \frac{m(v-u)}{10}$$

m (v–u) = 1000 Ns

The change in momentum (1000) N-s

350. If n bullets each of mass m are fired with a velocity v per second from a machine gun, the force required to hold the gun in position is

(a) (n + 1) mv
(b) $\frac{mv}{n^2}$
(c) $\frac{mv}{n}$
(d) n^2mv
(e) mnv

Kerala CEE - 2015

Ans. (e) : Given,

Number of bullet = n

Mass of bullet = m

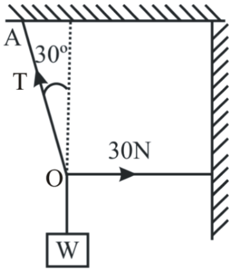
Velocity of bullet = v

The force required to hold the gun in position is

$$\text{Net force} = \Delta p/\Delta t = \frac{mnv}{1}$$

$$= mnv$$

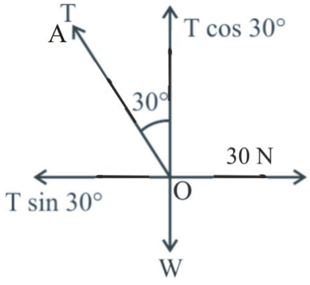
351. As shown in figure, the tension in the horizontal cord is 30 N. The weight W and tension in the string OA in Newton are



(a) $30\sqrt{3}, 30$
(b) $30\sqrt{3}, 60$
(c) $60\sqrt{3}, 30$
(d) None of the above

JCECE-2016

Ans. (b) : According to free body diagram –



According to figure,

$$W = T\sin30^\circ$$

$$30 = T\sin 30^\circ$$

$$T = 60 \text{ N}$$

Tension in cord, OA = 60 N

$$W = T\cos30^\circ$$

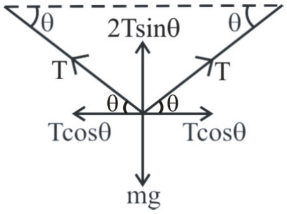
$$W = 60 \times \frac{\sqrt{3}}{2} = 30\sqrt{3} \text{ N}$$

352. A weight mg is suspended from the middle of a rope whose ends are at same level. If the rope is no longer horizontal. The minimum tension required to completely straighten the rope will be

(a) mg
(b) $\sqrt{mg}$
(c) Infinite
(d) Zero

JCECE-2013

Ans. (c) : According to free body diagram –



According to figure, $2T\sin\theta = mg$

$$T = \frac{mg}{2\sin\theta}$$

When rope is straight, θ = 0°

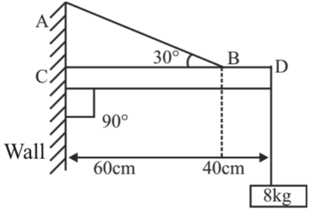
$$\because \quad T = \frac{mg}{2\sin 0^\circ} = \infty$$

This denotes that the minimum tension required to straighten the rope with weight suspended is infinite.

@apna_pdf

(d) Equilibrium of Concurrent Force

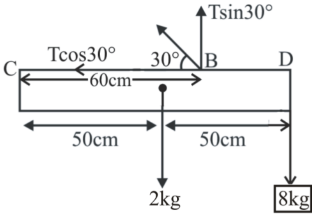
353. An object of mass 8kg is hanging from one and of a uniform rod CD of mass 2 kg and length 1m pivoted at its end C on a vertical wall as shown in figure. It is supported by a cable AB such that the system is in equilibrium. The tension in the cable is : (Take g = 10 m/s^2)



(a) 240 N (b) 30 N
(c) 300 N (d) 90N

JEE Main-25.01.2023, Shift-I

Ans. (c) : According to the free body diagram of uniform rod CD.

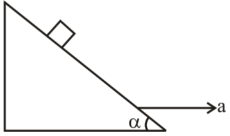


As system is in equilibrium net torque about point C=0

$$T\sin\frac{\pi}{6}\times 60-8g\times 100-2g\times 50=0$$

30T – 800 g – 100 g = 0
30T = 900 g
30T = 9000
T = 300 N

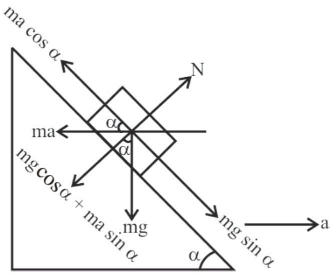
354. A block is kept on a frictionless inclined surface with angle of inclination 'α'. The incline is given an acceleration 'a' to keep the block stationary. Then 'a' is equal to



(a) g cosec α (b) g/tan α
(c) g tan α (d) g

BITSAT-2019
AIEEE-2005

Ans. (c) :



According to the figure, for block to remain stationary

ma cos α = mg sin α

$$a=\frac{g\sin\alpha}{\cos\alpha}$$

$a = g\tan\alpha$

355. Which of the following sets of concurrent force may be in equilibrium?

(a) $F_1=3N, F_2=5N, F_3=10N$
(b) $F_1=3N, F_2=5N, F_3=9N$
(c) $F_1=3N, F_2=5N, F_3=6N$
(d) $F_1=3N, F_2=5N, F_3=15N$

AP EAMCET (17.09.2020) Shift-II
Karnataka(CET-2003)

Ans. (c) : If three concurrent forces are to be in equilibrium, the sum of two smallest magnitude must be greater than the magnitude of third force.

i.e. $|\vec{F}_1|+|\vec{F}_2|\geq|\vec{F}_3|$

Now, we can substitute these values in the above equation, we get-

(c) F_1 = 3N, F_2 = 5N, F_3 = 6N
3 + 5 > 6

So, option (c) is right answer.

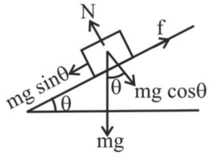
356. A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be :

(a) Mg (b) $Mg\cos\theta$
(c) $\sqrt{Mg\sin\theta+Mg\cos\theta}$ (d) $Mg\sin\theta\sqrt{1+\mu}$

JEE Main-27.07.2022, Shift-II

Ans. (a)

FBD of Body



Block slides down with constant velocity then net force on the block is zero.

So, Net contact force F_C on the body is $F_C=\sqrt{f^2+N^2}$

From the figure–

f = mg sinθ
N = mg cosθ

$$=\sqrt{(mg\sin\theta)^2+(mg\cos\theta)^2}$$

$$=\sqrt{(mg)^2\left[\sin^2\theta+\cos^2\theta\right]}$$

$F_C = mg$

357. Statement [A]: If a body is in equilibrium, then the resultant of the forces acting on the body is zero

Statement [B]: Action and reaction cancel each other as they act on the same body

Statement [C]: Centrifugal force is a pseudo force

@apna_pdf

Options:

(a) A, B, C are all true
(b) A, B are true but C is false
(c) A, C are true but B is false
(d) B, C are true but A is false

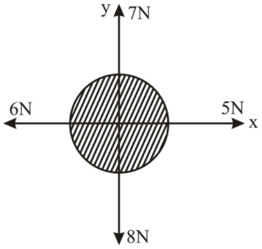
AP EAPCET-12.07.2022, Shift-II

Ans. (c) : A, C are true but B is false

Statement A: If a body is in equilibrium, then the resultant of the forces acting on the body is zero.

Statement C: Centrifugal force is a pseudo force because it is not provide by any real force but it arises due to accelerated frame of reference.

358. For a free body diagram shown in the figure, the four forces are applied in the 'x' and 'y' directions. What additional force must be applied and at what angle with positive x-axis so that the net acceleration of body is zero?



(a) $\sqrt{2}$N, 45°
(b) $\sqrt{2}$N, 135°
(c) $\frac{2}{\sqrt{3}}$N, 30°
(d) 2 N, 45°

JEE Main-25.07.2022, Shift-II

Ans. (a) : Assume addition force required is = $\vec{F}$

By figure,

$$\vec{F}+5\hat{i}-6\hat{i}+7\hat{j}-8\hat{j}=0$$

$$\vec{F}=\hat{i}+\hat{j}$$

$$|\vec{F}|=\sqrt{1^2+1^2}$$

$$|\vec{F}|=\sqrt{2}\text{ N}$$

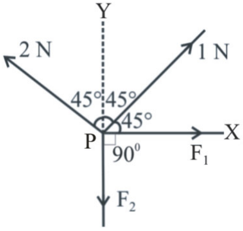
Angle with x axis-

$$\tan\theta=\frac{\text{y}-\text{component}}{\text{x}-\text{component}}=\frac{1}{1}$$

$$\tan\theta = 1 = \tan 45^\circ$$

$$\theta = 45^\circ$$

359. Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is 1 : x where x = _______.



JEE Main-25.07.2022, Shift-I

Ans. (3) : Given,

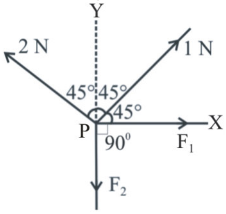
Four forces applying on body.

Find the value of F_1 and F_2.

Now,

Component 1N along the X-axis

Component 2 N along the Y-axis



For X- component,

$$F_1 - 2\sin 45^\circ + 1\sin 45^\circ = 0$$

$$F_1 = 2\sin 45^\circ - 1\sin 45^\circ$$

$$F_1 = 2\times\frac{1}{\sqrt{2}}-\frac{1}{\sqrt{2}}$$

$$F_1 = \frac{1}{\sqrt{2}}\text{N}$$

For Y- component,

$$F_2 - 2\cos 45^\circ - 1\cos 45^\circ = 0$$

$$F_2 = 2\cos 45^\circ + 1\cos 45^\circ$$

$$F_2 = 2\times\frac{1}{\sqrt{2}}+\frac{1}{\sqrt{2}}$$

$$F_2 = \frac{2}{\sqrt{2}}+\frac{1}{\sqrt{2}}$$

$$F_2 = \frac{3}{\sqrt{2}}\text{N}$$

According to the question, the Ratio of F_1 and F_2 is

$$\frac{F_1}{F_2}=\frac{1}{x}$$

Put the value of F_1 and F_2

$$\frac{1}{\sqrt{2}}\times\frac{\sqrt{2}}{3}=\frac{1}{x}$$

$$\frac{1}{x}=\frac{1}{3}$$

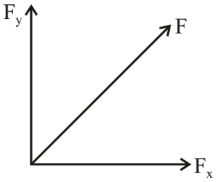
Hence, $x = 3$

360. One of the rectangular components of a force 40 N is $20\sqrt{3}$N. What is the other rectangular component?

(a) 10 N
(b) 20 N
(c) 30 N
(d) 25 N

AP EAMCET-19.08.2021, Shift-I

Ans. (b) : Given,



Rectangular component of 40 N force = $20\sqrt{3}$ N

Let, $F_x = 20\sqrt{3}$, $F = 40$ N

$F_y = ?$

We know that,

$$F^2 = F_x^2 + F_y^2$$

@apna_pdf

$$(40)^2 = (20\sqrt{3})^2 + F_y^2$$

$$1600 = 1200 + F_y^2$$

$$F_y^2 = 400 = 20 \times 20$$

$$F_y = 20$$

Hence, other component is = 20 N

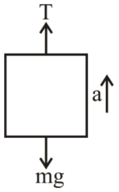
361. When a lift of mass 800 kg is ascending with an acceleration of 5 m.s^{-2}, the tension in its cable will be —— (take g = 10 m.s^{-2})

(a) 6000 N (b) 12000 N

(c) 4000 N (d) 50 N

AP EAMCET-06.09.2021, Shift-I

Ans. (b) :
Given that,
m = 800kg. a = 5m/sec^2 g = 10m/sec^2
Let the tension in the cable be T,
From eq. of motion for lift



$$T - mg = ma$$

$$T = ma + mg$$

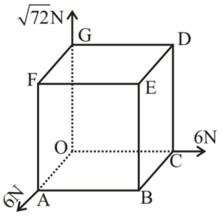
$$T = m(g + a) \quad \text{...(i)}$$

$$T = 800(10 + 5)$$

$$T = 12000 \text{ N}$$

Tension in its cable will be 12000 N.

362. Three forces of magnitude 6N, 6N and $\sqrt{72}$N act at a corner of a cube along three edges of a cube, as shown in the figure. The resultant of the three forces is ______.

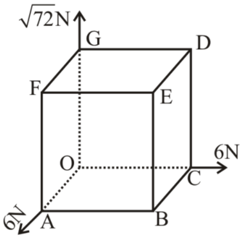


(a) 12N along OM (b) 18N along OA

(c) 18N along OC (d) 12N along OE

AP EAMCET-06.09.2021, Shift-II

Ans. (d) : Given,
Force along (OA) = 6N
Force along (OC) = 6N
Force along (OG) = $\sqrt{72}$N



The Resultant of these forces along OE is,

$$R = \sqrt{(OA)^2 + (OC)^2 + (OG)^2}$$

$$R = \sqrt{6^2 + 6^2 + (\sqrt{72})^2}$$

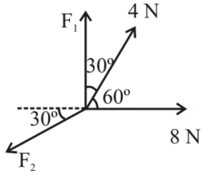
$$R = \sqrt{36 + 36 + 72}$$

$$R = \sqrt{144}$$

$$R = 12\text{N along OE}$$

Hence, the resultant of the three forces is 12 N along OE.

363. An object is in equilibrium when four concurrent forces, acting in the same plane, are in the directions shown in the figure. Find the magnitudes of F$_1$ and F$_2$.

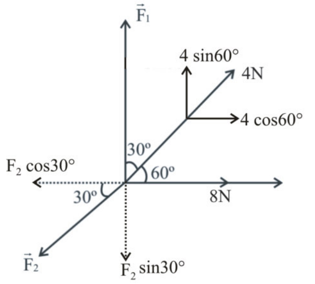


(a) $\frac{2}{\sqrt{3}}$N & $\frac{20}{\sqrt{3}}$N (b) $\frac{4}{\sqrt{3}}$N & $\frac{20}{\sqrt{3}}$ N

(c) $\frac{\sqrt{3}}{2}$N & $\frac{\sqrt{3}}{20}$N (d) $\frac{4}{\sqrt{3}}$N & $\frac{10}{\sqrt{3}}$N

AP EAMCET-25.08.2021, Shift-II

Ans. (b) : Given, object is in equilibrium.



(i) For all forces acting along the x-axis ($\Sigma F_x = 0$)

$$\therefore 8 + 4\cos 60^\circ - F_2 \cos 30^\circ = 0$$

$$8 + 2 - F_2\frac{\sqrt{3}}{2} = 0$$

$$F_2 = \frac{20}{\sqrt{3}} \text{N}$$

Now,

(ii) For the force acting in along the y-axis ($\Sigma F_y = 0$)

$$\therefore F_1 + 4\sin 60^\circ - F_2 \sin 30^\circ = 0$$

$$F_1 + \frac{4\sqrt{3}}{2} - \frac{F_2}{2} = 0$$

$$F_1 = \frac{F_2}{2} - 2\sqrt{3} = \frac{10}{\sqrt{3}} - 2\sqrt{3}$$

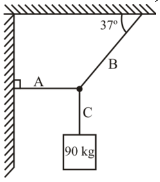
$$F_1 = \frac{4}{\sqrt{3}} \text{N}$$

Hence, magnitude of F$_1$ = $\frac{4}{\sqrt{3}}$N and

Magnitude of F$_2$ = $\frac{20}{\sqrt{3}}$N

@apna_pdf

364. A block of mass 90 kg is suspended by three strings A, B and C as shown in figure. Tensions in the strings A, B and C respectively are ____ ($g = 10 m.s^{-2}$ sin 37°= 0.6, cos37° = 0.8)

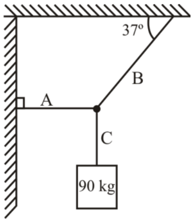


(a) 400N, 500N & 300N
(b) 500N, 300N & 900N
(c) 300N, 600N & 900N
(d) 1200N, 1500N & 900N

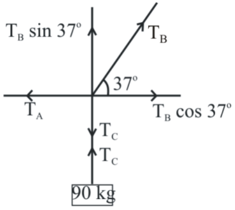
AP EAMCET-23.08.2021, Shift-I

Ans. (d) : Given,
Mass of block (m) = 90 kg

$g = 10\ ms^{-2}$
$\sin 37^o = 0.6$
$\cos 37^o = 0.8$



Free Body Diagram



$\sum F_y = 0$
$T_c = 90$ kg
We know that,
$T_c = 90 \times 10$ N
$\boxed{T_c = 900\ N}$
Now,
$T_B \sin 37^o = T_c$
$T_B \sin 37^o = 900$ N

$$T_B = \frac{900}{\sin 37^o}$$

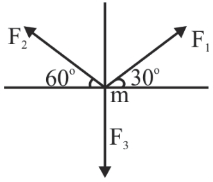
$$T_B = \frac{900}{0.6}$$

$$\boxed{T_B = 1500N}$$

$\sum F_x = 0$
Then,
$T_B \cos 37^o = T_A$
$T_A = T_B \cos 37^o$
$T_A = 1500 \times 0.8$
$\boxed{T_A = 1200N}$

Hence, the tension in the string A, B, C are 1200N, 1500N, 900N.

365. A box of mass m is in equilibrium under the application of three forces as shown below. If the magnitude of F_1 is 10 N, what is the magnitude of F_3?

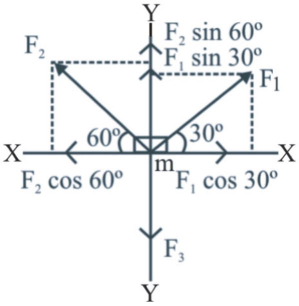


(a) 5N
(b) 15N
(c) 20N
(d) 30N

TS-EAMCET.14.09.2020, Shift-2

Ans. (c) : Given that, $|\vec{F}_1| = 10N$

The box of mass m is in equilibrium under three forces.



After resolving the forces in X and Y axes we get -
The forces in x - direction

$$|\vec{F}_2| \cos 60^o = |F_1| \cos 30^o$$

$$|\vec{F}_2| \times \frac{1}{2} = 10 \times \frac{\sqrt{3}}{2} \qquad (\because |F_1| = 10N|)$$

$$|\vec{F}_2| = 10\sqrt{3}\ N$$

Again the forces in Y-direction

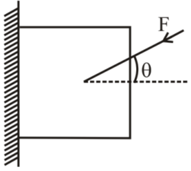
$$|F_3| = |F_1| \sin 30^o + |F_2| \sin 60^o$$

$$= 10 \times \frac{1}{2} + 10\sqrt{3} \times \frac{\sqrt{3}}{2}$$

$$= \frac{40}{2} = 20N$$

Hence, the magnitude of F_3 = 20 N.

366. A block of mass 3 kg is pressed against a vertical wall by applying a force F at an angle 30° to the horizontal as shown in the figure. As a result, the block is prevented from falling down. If the coefficient of static friction between the block and wall is $\sqrt{3}$, then the value of F is (use, $g = 10\ m/s^2$)

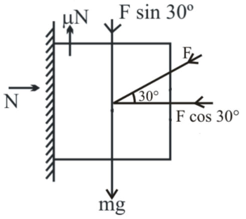


(a) 30 N
(b) $15\sqrt{3}$ N
(c) $60\sqrt{3}$ N
(d) 60 N

TS-EAMCET-10.09.2020, Shift-2

@apna_pdf

Ans. (a) : Given,
Mass of block (m) = 3 kg
Static friction $(\mu) = \sqrt{3}$



Normal reaction by the wall against force

$$N = F\cos 30° = \frac{\sqrt{3}}{2}F$$

∵ The friction force against the sliding of the box-

$$f = \mu N$$

$$f = \sqrt{3}\times\frac{\sqrt{3}}{2}F = \frac{3}{2}F$$

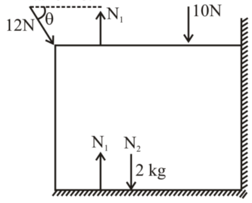
As the block is in equilibrium state so, friction force = weight of block (mg) + vertical component of block

$$\frac{3}{2}F = 3\times10 + F\sin 30°$$

$$\frac{3}{2}F = 30 + \frac{F}{2}$$

$$F = 30\text{ N}$$

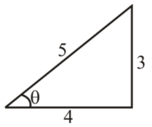
367. A block is between two surfaces as shown in the figure. Find the normal reaction at both surfaces. [Assume $g = 10\text{ m/s}^2$]



(a) $N_1 = 37.2$ N and $N_2 = 9.6$ N
(b) $N_1 = 38.2$ N and $N_2 = 8.6$ N
(c) $N_1 = 40$ N and $N_2 = 4$N
(d) $N_1 = 37.5$ N and $N_2 = 9.9$ N

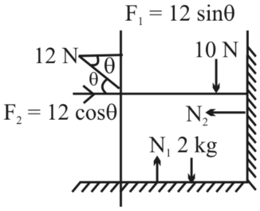
TS-EAMCET-10.09.2020, Shift-1

Ans. (a) : Given , $\tan\theta = \frac{3}{4}$



So, $\sin\theta = \frac{3}{5}$ and $\cos\theta = \frac{4}{5}$

Extracting the force applied on the block in X and Y axis -



Vertical component$(F_1) = 12\sin\theta \times 3/5$
So, the total force applied on the ground
= 10 N + vertical component force + 2 × 10
= $(10 + 12\sin\theta + 2\times 10)$ N

$$= 30 + 12\times\frac{3}{5} = 37.2\text{ N}$$

Thus, $N_1 = 37.2$ N
Total force applied on the wall = $12\cos\theta$

$$= 12\times\frac{4}{5} = \frac{48}{5} = 9.6\text{N}$$

Thus, reaction force of wall $(N_2) = 9.6$ N

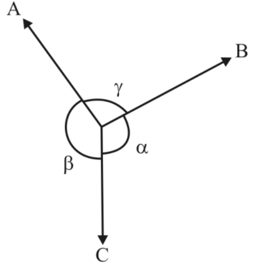
368. Three concurrent forces of the same magnitude are in equilibrium. What is the angle between the forces? Also, name the triangle formed by the forces as sides

(a) 60° equilateral triangle
(b) 120° equilateral triangle
(c) 120°, 30°, 30° an isosceles triangle
(d) 120° an obtuse triangle

Manipal UGET-2018

Ans. (b) : According to Lami's theorem, when three forces acting at a point are in equilibrium then each force is proportional to the sine of the angle between the other two forces.

If forces A, B and C are in equilibrium then-



$$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$$

As the forces are equal in magnitude, $\alpha = \beta = \gamma$

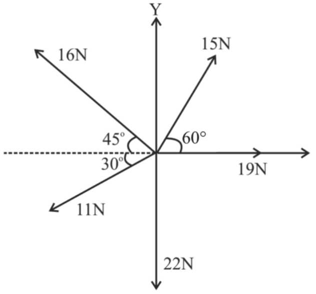
We know, $\alpha + \beta + \gamma = 360°$

$$3\alpha = 360°$$

$$\alpha = 120°$$

Therefore the angle $\alpha = 120°$, $\beta = 120°$ and □ = 120° between the forces form equilateral triangle.

369. Consider an object kept at the centre, in the *XY*-plane, on which five coplanar forces act as shown in the figure. The resultant force on the object is

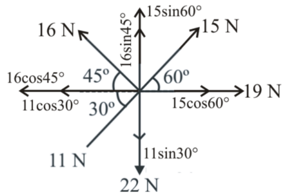


(a) 6.5 N, 330°
(b) 6.5 N, 300°
(c) 6.5 N, 30°
(d) 5.7 N, 331°

TS-EAMCET-04.05.2018, Shift-2

@apna_pdf

Ans. (a) :



After resolving all forces into x and y plane, we get,
Total force in x - direction

$F_x = 15\cos 60° + 19 - (16\cos 45° + 11\cos 30°)$

$$= 15\times\frac{1}{2} + 19 - \left(16\times\frac{1}{\sqrt{2}} + 11\times\frac{\sqrt{3}}{2}\right)$$

$= 26.5 - (11.31 + 9.52)$

$= 26.5 - 20.83 = 5.67\ N$

Total Force in y - direction

$f_y = (16\sin 45° + 15\sin 60°) - (11\sin 30 + 22)$

$$\left(16\times\frac{1}{\sqrt{2}} + 15\times\frac{\sqrt{3}}{2}\right) - \left(\frac{11}{2} + 22\right)$$

$= (11.31 + 12.99) - (27.5) = -3.2\ N$

Now, Resultant force

$$F = \sqrt{F_x^{\ 2} + F_y^{\ 2}}$$

$$F = \sqrt{(5.67)^2 + (-3.2)^2} = 6.5\ N$$

Direction of Resultant force

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{-3.2}{5.67}\right) = 330°$$

370. The magnitudes of a set of 3 vectors are given below. The set of vectors for which the resultant cannot be zero is

(a) 15, 20, 30 (b) 20, 20, 30
(c) 25, 20, 35 (d) 10, 10, 20
(e) 10, 20, 40

Kerala CEE - 2015

Ans. (e) : According to the triangle law, the addition of first two vectors is greater than third vector. For the resultant cannot be zero. But in option (e) can not satisfied.

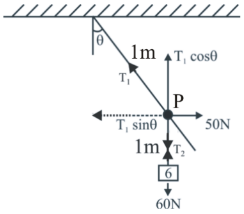
i.e. $10 + 20 < 40$

371. A mass of 6 kg is suspended by a rope of length 2m from a ceiling. A force of 50 N in the horizontal direction is applied at the mid- point P of the rope. The angle made by the rope with the vertical, in equilibrium is

(a) 50° (b) 60°
(c) 30° (d) 40°
(e) 45°

Kerala CEE 2007

Ans. (d) : The given system is in equilibrium



From figure, $T_1\cos\theta = 60N$ .....(i)

$T_1\sin\theta = 50N$ ....(ii)

Dividing equation (ii) by (i) we get –

$$\frac{T_1\sin\theta}{T_1\cos\theta} = \frac{50}{60}$$

$$\tan\theta = \frac{5}{6}$$

$\theta = \tan^{-1}(5/6) = 40°$

372. The sum of the magnitudes of two forces acting at a point is 18 N and the magnitude of their resultant is 12 N. If the resultant is at 90° with the smaller force, the magnitude of the forces in N are

(a) 6, 12 (b) 11, 7
(c) 5, 13 (d) 14, 4
(e) 10, 8

Kerala CEE 2007

Ans. (c) : Let smaller force be F_1 and F_2 be the greater force then, $F_1 + F_2 = 18\ N$ ….(i)

Resultant R of the forces is 90° to AB (i.e. F_1),

or $(12)^2 = F_2^2 - F_1^2$

or $144 = (F_2 - F_1)(F_2 + F_1)$

∴ $(F_2 - F_1)\times 18 = 144$

$$(F_2 - F_1) = \frac{144}{18} = 8 \quad ….(ii)$$

Adding equation (i) and (ii), we get

$F_1 + F_2 + F_2 - F_1 = 18 + 8$

$2F_2 = 26$

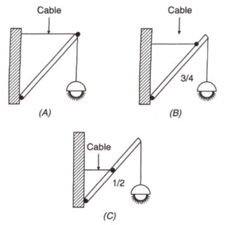
$F_2 = 13\ N$

Putting the value of F_2 in equation (i) we get –

$F_1 + 13 = 18$

$F_1 = 5\ N$

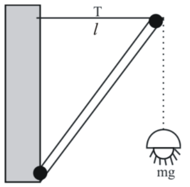
373. If a street light of mass M is suspended from the end of a uniform rod of length L in different possible patterns as shown in figure, then :



(a) Pattern A is more sturdy
(b) Pattern B is more sturdy
(c) Pattern C is more sturdy
(d) all will have same sturdiness

UPSEE - 2006

Ans. (a) :



@apna_pdf

Due to same weight of street light in all three cases torque will be same.

If T is tension and l be perpendicular distance of cable from the axis then

$$\tau = T \times l$$

$$T \times l = \text{constant} \qquad (\tau \text{ is constant})$$

$$T \propto \frac{1}{l}$$

Hence, tension will be least for largest cable. So pattern A is more sturdy.

374. The resultant of two forces acting at an angle of 120° is 10 kg-wt and is perpendicular to one of the forces. That force is:

(a) $10\sqrt{3}$ kg-wt (b) $20\sqrt{3}$ kg-wt

(c) 10 kg-wt (d) $\frac{10}{\sqrt{3}}$ kg-wt

Karnataka CET-2011

Ans. (d) : Given,

F = 10 kg-wt

F = 120°

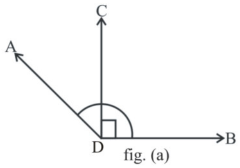


fig. (a)

From fig (a)

Here,

A and B are two forces acting from the same point and C is their resultant,

So, the angle b/w the two forces A and B is 120^o.

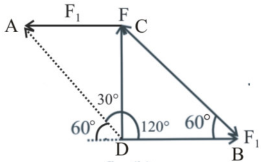


fig (b)

From figure (b)

In ΔACD

$$\tan\theta = \frac{\text{force that we need to find}}{\text{resultant force}} = \frac{AC}{CD}$$

$$\tan 30^o = \frac{F_1}{F}$$

$$F_1 = F \tan 30^o$$

$$F_1 = 10 \times \frac{1}{\sqrt{3}} \text{kg-wt}$$

375. A steel wire can withstand a load up to 2940 N. A load of 150 kg is suspended from a rigid support. The maximum angle through which the wire can be displaced from the mean position, so that the wire does not break when the load passes through the position of equilibrium, is

(a) 30^o (b) 60^o

(c) 80^o (d) 85^o

EAMCET-2008

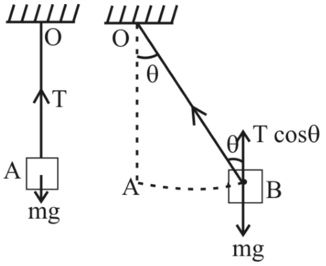
Ans. (b) : Given,

Load (T) = 2940 N

Mass (m) = 150 kg

$g = 9.8 \text{ m/s}^2$

$\theta = ?$



(I) Initial condition (II) Maximum angle conditon

At point B in (ii) Figure in equilibrium condition

$$T \cos\theta = mg$$

$$\cos\theta = \frac{mg}{T}$$

$$\cos\square = \frac{150 \times 9.8}{2940}$$

$$\cos\theta = 0.5 = \frac{1}{2}$$

$$\cos\theta = \cos 60^\circ$$

$$\Rightarrow \quad \theta = 60^\circ$$

Hence, the maximum angle θ = 60° at which the wire can be displaced from the mean position.

376. Which one among the following is the correct for resultant of balanced forces?

(a) It is zero

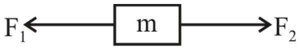
(b) It is non-zero

(c) It varies continuously

(d) None of the above

NDA (II) 2011

Ans. : (a) Balanced forces- When two forces acting on an object are equal in size but act in opposite directions they are called balanced forces.



$$\vec{F}_{net} = \vec{F}_1 - \vec{F}_2 \qquad (\because \vec{F}_1 = \vec{F}_2)$$

$$F_{net} = \vec{F}_1 - \vec{F}_1$$

$$\vec{F}_{net} = 0$$

The resultant of balanced forces is zero.

377. Forces of 5 N, 12 N and 13 N are in equilibrium. If $\sin 23^\circ = \frac{5}{13}$, then the angle between 5 N and 13 N forces is

(a) 23° (b) 67°

(c) 90° (d) 113°

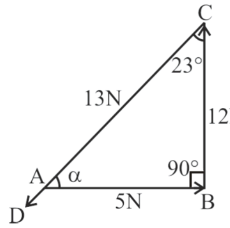
Assam CEE-2014

Ans. (b) : Given,

Forces 5N, 12N, 13 N are in Equilibrium.

Given, $\sin 23^\circ = \frac{5}{13}$

@apna_pdf



We know, in ΔABC

$\angle A + \angle B + \angle C = 180°$

$\alpha + 90° + 23° = 180°$

$\alpha = 180° - 113°$

$\alpha = 67°$

378. The sum of magnitudes of two forces acting at a point is 16 N. If their resultant is normal to smaller force, and has a magnitude 8 N, then forces are

(a) 6 N, 10 N
(b) 8 N, 8 N
(c) 4 N, 12 N
(d) 2 N, 14 N

AP EAMCET -2012

Ans. (a) : Let a and b is two forces.
Then given,

$$|\vec{a}| + |\vec{b}| = 16\,N,\ |\vec{R}| = 8\,N$$

$\therefore \quad \vec{R} = \vec{a} + \vec{b}$

Squaring both side,

$$\left(\vec{R}\right)^2 = \left(\vec{a} + \vec{b}\right)^2$$

$$|\vec{R}| = \sqrt{a^2 + b^2 + 2ab\cos\theta}$$

Let, $\vec{a} > \vec{b}$

$$\vec{R}.\vec{b} = 0$$

$$\left(\vec{a} + \vec{b}\right).\vec{b} = 0$$

$$\vec{a}.\vec{b} = -(b)^2$$

ab cos□ = –b^2 ….(i)

$$8 = \sqrt{(16-b)^2 + b^2 + 2(-b)^2}$$

Squaring both side-

$64 = 256 + b^2 - 32b + b^2 - 2b^2$

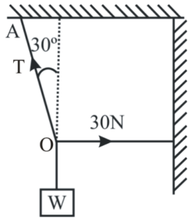
$32b = 256 - 64$

$32b = 192$

$b = 6\,N$

$\therefore \quad a = 16 - 6 = 10\,N$

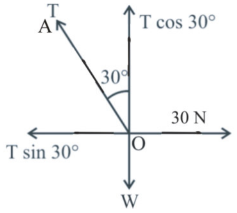
379. As shown in figure, the tension in the horizontal cord is 30 N. The weight W and tension in the string OA in Newton are



(a) $30\sqrt{3}, 30$
(b) $30\sqrt{3}, 60$
(c) $60\sqrt{3}, 30$
(d) None of the above

JCECE-2016

Ans. (b) : According to free body diagram –



According to figure, $W = T\cos 30°$

$30 = T\sin 30°$

$T = 60\ N$

Tension in cord, OA = 60 N

$W = T\ \cos 30°$

$$W = 60 \times \frac{\sqrt{3}}{2} = 30\sqrt{3}\,N$$

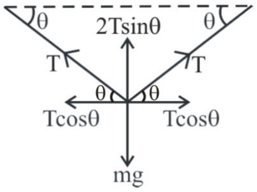
Hence, the correct answer is option (b).

380. A weight mg is suspended from the middle of a rope whose ends are at same level. If the rope is no longer horizontal. The minimum tension required to completely straighten the rope will be

(a) mg
(b) $\sqrt{mg}$
(c) Infinite
(d) Zero

JCECE-2013

Ans. (c) : According to free body diagram –



According to figure, $2T\sin\theta = mg$

$$T = \frac{mg}{2\sin\theta}$$

When rope is straight, $\theta = 0°$

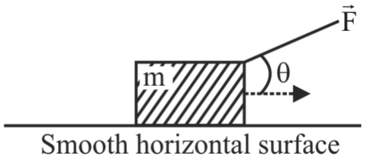
$$\because \quad T = \frac{mg}{2\sin 0°} = \infty$$

This denotes that the minimum tension required to straighten the rope with weight suspended is infinite.

(e) Forces in Mechanism

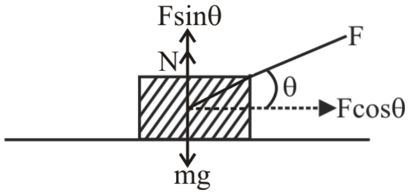
381. An object of mass 'm' initially at rest on a smooth horizontal plane starts moving under the action of force F = 2N. In the process of its linear motion, the angle θ (as shown in figure) between the direction of force and horizontal varies as θ = kx, where k is a constant and x is the distance covered by the object from its initial position. The expression of kinetic energy of the object will be $E = \frac{n}{k}\sin\theta$. The value of n is

@apna_pdf



JEE Main-25.01.2023, Shift-I

Ans. (2) : From free body diagram,



∴ $F\cos\theta = ma$

$$2\cos(kx) = \frac{mvdv}{dx}$$

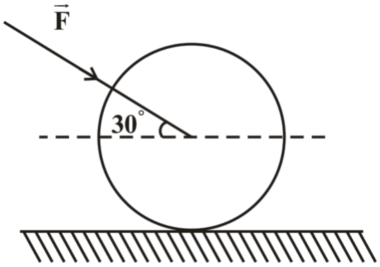
$$m\int_0^v vdv = 2\int_0^x \cos(kx)dx$$

$$\frac{mv^2}{2} = \frac{2}{k}\sin kx$$

$$K.E = \frac{2}{k}\sin\theta$$

Hence, the value of n = 2.

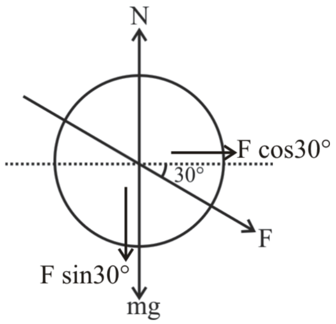
382. As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200N$ at an angle of 30° with horizontal. the normal reaction on the roller is (Given, g =$10ms^{-2}$)



(a) 800 N
(b) 600N
(c) $200\sqrt{3}N$
(d) $800\sqrt{2}$ N

JEE Main-31.01.2023, Shift-I

Ans. (a) : Given, mass of garden roller = 70 kg



Therefore, $N = mg + F\sin30^\circ$

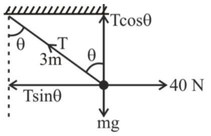
$$N = 700 + 200 \times \frac{1}{2} = 800 \text{ N}$$

383. A block of mass 8 kg is suspended by a rope of length 3m from the ceiling. A force of 40 N is applied horizontally to the block. Then the angle that the rope makes with the vertical in equilibrium is
(acceleration due to gravity = 10 ms^{-2}, neglect the mass of the rope)

(a) $\sin^{-1}\frac{1}{2}$
(b) $\tan^{-1}\frac{1}{2}$
(c) $\sin^{-1}\frac{1}{3}$
(d) $\tan^{-1}\frac{1}{3}$

AP EAMCET-08.07.2022, Shift-I

Ans. (b) : Given, mass (m) = 8 kg = 80 N
Length of the rope = 3 m



Let θ angle make by the rope with vertical for equilibrium–
From the figure,

$$\sum F_x = 0$$

$T\sin\theta = 40$ …(i)

And

$$\sum F_y = 0$$

$T\cos\theta = mg$

$T\cos\theta = 80$ …(ii)

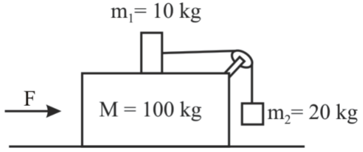
From equation (i) / (ii), we get–

$$\frac{T\sin\theta}{T\cos\theta} = \frac{40}{80}$$

$$\tan\theta = \frac{40}{80}$$

$$\theta = \tan^{-1}(1/2)$$

384. Three masses M = 100 kg, m_1 = 10 kg, and m_2 = 20 kg are arranged in a system as shown in figure. All the surfaces are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of $2ms^{-2}$. The value of F is :
(Take g = 10 ms^{-2})

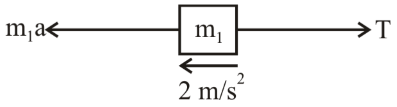


(a) 3360 N
(b) 3380 N
(c) 3120 N
(d) 3240 N

JEE Main-26.07.2022, Shift-I

Ans. (c) : In frame of block of mass M moving with acceleration a.

FBD of 10 kg block w.r.t. 100 kg

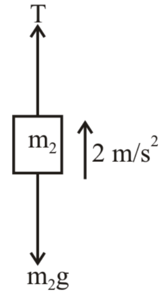


@apna_pdf

$m_1a - T = 2m_1$

$10a - T = 20 \quad \ldots(i)$

Now, FBD of 20 kg block w.r.t. 100 kg-



$T - m_2g = m_2.2$

$T - 20 \times 10 = 20 \times 2$

$T - 200 = 40$

$T = 240 \quad \ldots(ii)$

From equation (i) and (ii)

$10a - 240 = 20$

$10a = 260$

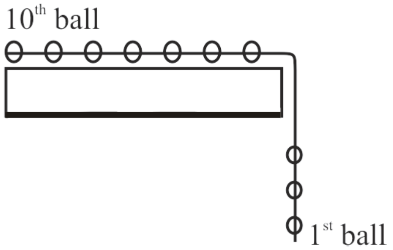
$a = 26\ m/s^2$

For block m_2-

$F = (M + m_2)a = 120 \times 26$

$F = 3120$ N

385. A system to 10 balls each of mass 2 kg are connected via mass less and stretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is ——— N when 6th ball just leaves the table.



JEE Main-26.06.2022, Shift-II

Ans. (36) : At given instant –

Acceleration, $a_{system} = \frac{6mg}{10m} = \frac{6g}{10} = \frac{3g}{5}$

Taking 8,9,10 together

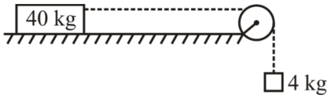
$\therefore\ T = 3ma_{system}$

$= 3m \times \frac{3g}{5}$

$= 3 \times 2 \times \frac{3 \times 10}{5} \quad (g = 10\ m/sec^2)$

$= 36$ N

386. A block of mass 40 kg sliders over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is. (Given g = 10 ms^{-2})



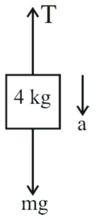
(a) 1 ms^{-2} (b) 1/5 ms^{-2}

(c) 4/5 ms^{-2} (d) 8/11 ms^{-2}

JEE Main-29.06.2022, Shift-II

Ans. (d) : Given, μ = 0.02

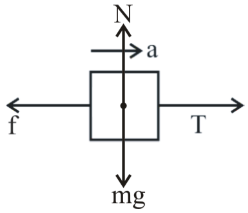
For 4 kg block,



$mg - T = ma$

$4g - T = 4a \quad \ldots(i)$

For 40 kg block,



$T - f = ma$

$T - \mu N = ma$

$T - \mu\ mg = ma$

$T - 0.02 \times 40\ g = 40a \quad \ldots(ii)$

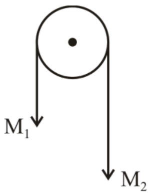
On adding equation (i) & equation (ii), we get–

$40 - 8 = 44a$

$44a = 32$

$a = \frac{8}{11} m/s^2$

387. Two masses M_1 and M_2 are tied together at the two ends of a light inextensible string that passes over a frictionless pulley. When the mass M_2 is twice that of M_1, the acceleration of the system is a_1. When the mass M_2 is thrice that of M_1. The acceleration of the system is a_2. The ratio $\frac{a_1}{a_2}$ will be:



(a) $\frac{1}{3}$ (b) $\frac{2}{3}$

(c) $\frac{3}{2}$ (d) $\frac{1}{2}$

JEE Main-26.07.2022, Shift-II

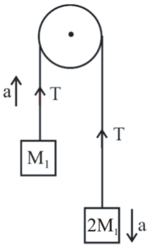
@apna_pdf

Ans. (b) : According to the question –

Case-I :

When, $M_2 = 2M_1$

Then, Acceleration = a_1



So, for M_1 block,

$$T - M_1g = M_1a_1 \quad \ldots(i)$$

For M_2 block,

$$M_2g - T = M_2a_1 \quad (\because M_2 = 2M_1)$$

$$2M_1g - T = 2M_1a_1 \quad \ldots(ii)$$

On adding equation (i) & equation (ii), we get–

$$M_1g = 3M_1a_1$$

$$a_1 = g/3$$

Case-II :

When, $M_2 = 3M_1$

Then, Acceleration = a_2

So, for block M_1,

$$T - M_1g = M_1a_2 \quad \ldots(i)$$

For block M_2,

$$M_2g - T = M_2a_2$$

$$3M_1g - T = 3M_1a_2 \quad \ldots(ii) \ [\because M_2 = 3M_1]$$

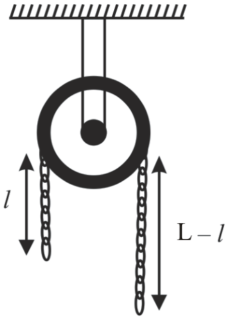
From eq^n (i) & eq^n (ii), we get–

$$2M_1g = 4M_1a_2$$

$$a_2 = g/2$$

Hence, $\frac{a_1}{a_2} = \frac{g/3}{g/2} = \frac{2}{3}$

388. A uniform metal chain of mass M and length 'L' passes over a massless and frictionless pulley. It is released from rest with a part of its length '*l*' is hanging on one side and rest of its length 'L –*l*' is hanging on the other side of the pulley. At a certain point of time, when $\ell = \frac{L}{x}$, the acceleration of the chain is $\frac{g}{2}$. The value of x is…..

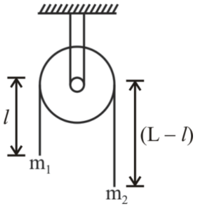


(a) 6 (b) 2

(c) 1.5 (d) 4

JEE Main-28.07.2022, Shift-II

Ans. (d) :



We know,

Acceleration of chain is–

$$a = \frac{(m_2 - m_1)}{(m_2 + m_1)}g$$

Given, $a = \frac{g}{2}$

So, $\frac{g}{2} = \frac{(m_2 - m_1)}{(m_2 + m_1)}g$

$$2m_2 - 2m_1 = m_2 + m_1$$

$$3m_1 = m_2 \quad \ldots..(i)$$

Now, from figure,

$m_2 = (L - l)\lambda$ (where, λ = mass per unit length)

$$m_1 = l\lambda$$

From equation (i), we get–

$$3l\lambda = (L - l)\lambda$$

$$4l = L$$

$$l = \frac{L}{4}$$

Compare to $l = \frac{L}{x}$ from question

We get, x = 4

389. A pulley of radius 1.5 m is rotated about its axis by a force F= $(12t–3t^2)$N aligned tangentially (while t is measured in seconds). If moment of inertia of the pulley about its axis of rotation is 4.5 kg m^2, the number of rotations made by the pulley before its direction of motion is reversed, will be $\frac{K}{\pi}$. The value of K is _____.

JEE Main-27.07.2022, Shift-I

Ans. (18) : Given,

Radius of pulley = 1.5 m

Force (F) = $(12t - 3t^2)$N

MOI (I) = 4.5 kgm^2

∴ Torque acting on the pully by the applied force is given by–

$$\tau = (12t - 3t^2)1.5$$

$$= (18t - 4.5t^2)\text{Nm}$$

For this, we find angular acceleration–

$$\alpha = \frac{\tau}{I} = \frac{18t - 4.5t^2}{4.5} = (4t - t^2)$$

To find angular speed, we use–

$$\omega = \int_0^t \alpha dt$$

$$= \int_0^t (4t - t^2)dt = 2t^2 - \frac{t^3}{3}$$

@apna_pdf

When direction is reversed, ω is zero so,

$$2t^2 - \frac{t^3}{3} = 0$$

$$t^3 = 6t^2$$

$$t = 6\text{sec}$$

Now, angular displacement–

$$\theta = \int_0^6 \omega dt$$

$$\theta = \int_0^6 \left(2t^2 - \frac{t^3}{3}\right) dt$$

$$\theta = \left[\frac{2t^3}{3} - \frac{t^4}{12}\right]_0^6 = 36 \text{ rad}$$

We know,

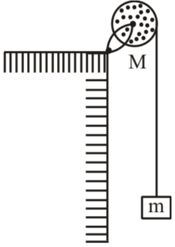
1 rev = 2π rad

$$\therefore \text{ Total no. of revolution before reversal } = \frac{36}{2\pi} = \frac{18}{\pi}$$

To compare with $\frac{K}{\pi}$ we get

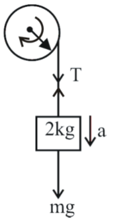
K = 18

390. A uniform disc with mass M=4kg and radius R=10 cm is mounted on a fixed horizontal axle as shown in figure. A block with mass m=2 kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the block, the cord does not slip and there is no friction at the axle. The tension in the cord is _____N.
(Take g=10 ms^{-2})



JEE Main-28.06.2022, Shift-II

Ans. (10) : For this figure,



For block m = 2kg

$$mg - T = ma$$

$$2g - T = 2a \quad .....(i)$$

We know,

$$\tau = I\alpha$$

$$T \cdot R = \frac{MR^2}{2}\alpha \qquad \left(\text{For disc } I = \frac{MR^2}{2}\right)$$

$$T = \frac{MR\alpha}{2} \quad .....(ii)$$

And, linear acceleration (a) = R × α

$$\alpha = \frac{a}{R}$$

Put this value in equation (ii), we get–

$$T = \frac{Ma}{2} = \frac{4a}{2} \qquad (\because M = 4\text{kg})$$

$$\therefore \quad T = 2a \quad .....(iii)$$

So, from equation (i), we get–

$$2g - T = 2a$$

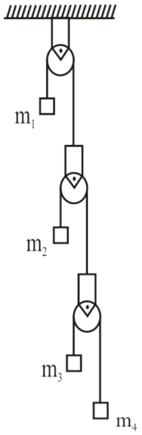
$$2g - T = T \qquad [\text{From (iii)}, T = 2a]$$

$$2 \times 10 = 2T$$

$$20 = 2T$$

$$T = 10 \text{ N}$$

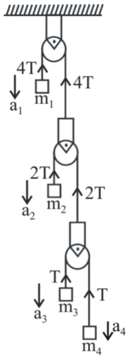
391. In the arrangement shown in figure a_1, a_2, a_3, and a_4 are the accelerations of masses m_1, m_2, m_3, and m_4 respectively. Which of the following relation is true for this arrangement?



(a) $4a_1 + 2a_2 + a_3 + a_4 = 0$
(b) $a_1 + 4a_2 + 3a_3 + a_4 = 0$
(c) $a_1 + 4a_2 + 3a_3 + 2a_4 = 0$
(d) $2a_1 + 2a_2 + 3a_3 + a_4 = 0$

JEE Main-26.06.2022, Shift-II

Ans. (a) :



Using constraints,

$$\Sigma \vec{T} \cdot \vec{a} = 0$$

$$-4Ta_1 - 2Ta_2 - Ta_3 - Ta_4 = 0$$

$$4a_1 + 2a_2 + a_3 + a_4 = 0$$

392. A cylinder of mass 12 kg is sliding on plane with an initial velocity 20 ms^{-1} . If the coefficient of friction between the surface and the cylinder is 0.5, before stopping. The cylinder describes a distance of _______.

@apna_pdf

(a) 40 m (b) 5 m
(c) 20 m (d) 10 m

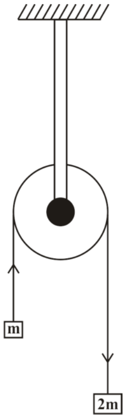
AP EAMCET-23.08.2021, Shift-II

Ans. (a) : Given,
$m = 12$ kg
$u = 20\ ms^{-1}$
$\mu = 0.5$
We know that
Friction force (f) $= \mu N = \mu mg \qquad [\therefore N = mg]$
$= 0.5 \times 12 \times 10$
$f = 60$
$\because \quad f = -ma$

$$\text{Acceleration } (a) = -\frac{f}{m} = -\frac{60}{12} = -5ms^{-2}$$

From Newton's third law of motion,
$v^2 = u^2 + 2as$
$0 = (20)^2 + 2 \times (-5) \times s$
$0 = 400 - 10s$
$s = 40$ m
So, cylinder describes distance of 40 m before stopping.

393. Two masses m and 2m are hang from a frictionless. Weightless ideal pulley as shown below:

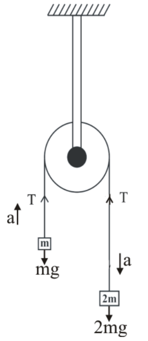


The upward acceleration of the mass m is

(a) $\frac{g}{8}$ (b) $\frac{g}{4}$
(c) $\frac{g}{3}$ (d) $\frac{g}{2}$

Tripura-2020

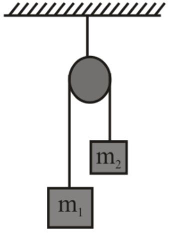
Ans. (c) :



$2mg - T = 2ma \qquad \ldots(i)$
And $\quad T - mg = ma \qquad \ldots(ii)$
By adding equation (i) and (ii)
$2mg - mg = 3\ ma$
$mg = 3ma$

$$\boxed{a = \frac{g}{3}}$$

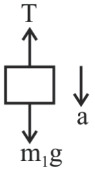
394. Two masses m_1= 5kg and m_2= 4.8 kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses. When left free to move? ($g = 9.8m.s^{-2}$)



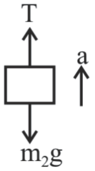
(a) $0.2\ m.s^{-2}$ (b) $9.8\ m.s^{-2}$
(c) $5.0\ m.s^{-2}$ (d) $4.8\ m.s^{-2}$

AP EAMCET-24.09.2020, Shift-II

Ans. (a) : Given,
$m_1 = 5$ kg
$m_2 = 4.8$ kg
$g = 9.8\ ms^{-2}$
FBD for block m_1-



$m_1g - T = m_1a \qquad \ldots(i)$
FBD for block m_2-



$T - m_2g = m_2a \qquad \ldots(ii)$
On adding equation (i) and equation (ii), we get–
$m_1g - m_2g = m_1a + m_2a$
$g(m_1 - m_2) = a(m_1 + m_2)$

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

By putting the value,

$$a = \frac{(5 - 4.8) \times 9.8}{5 + 4.8}$$

$a = 0.2\ ms^{-2}$

395. The maximum and minimum tensions in a string whirling in a circle of radius 2.5 m are in the ratio 5 : 3. Then, its velocity is ………. $m.s^{-1}$:

(a) 7 (b) $\sqrt{98}$
(c) $\sqrt{4.9}$ (d) $\sqrt{490}$

AP EAMCET-25.09.2020, Shift-I

@apna_pdf

Ans. (b) : Given, radius of circle (r) = 2.5 m

It is assumed that particle although moving in a vertical loop but its speed is constant.

Tension of lowest point–

$$T_{max} = \frac{mv^2}{r} + mg \qquad .....(i)$$

Tension of highest point–

$$T_{min.} = \frac{mv^2}{r} - mg \qquad .....(ii)$$

Dividing equation (i) by (ii), we get–

$$\frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{r} + mg}{\frac{mv^2}{r} - mg} = \frac{5}{3} \qquad \left[\frac{T_{max}}{T_{min}} = \frac{5}{3}(\text{given})\right]$$

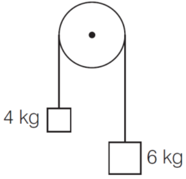
$$\frac{v^2 + gr}{v^2 - gr} = \frac{5}{3}$$

$$v = \sqrt{4gr}$$

$$v = \sqrt{4 \times 9.8 \times 2.5}$$

$$v = \sqrt{98}\ ms^{-1}$$

396. Two bodies of mass 4 kg and 6 kg are tied to the ends of a massless string. The string passes over a pulley which is frictionless (see figure). The acceleration of the system in terms of acceleration due to gravity g is

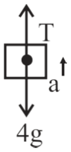


(a) g/2 (b) g/5
(c) g/10 (d) g

NEET- (Sep.) 2020

Ans. (b) : Given, $m_1 = 4kg$, $m_2 = 6kg$

For block A –

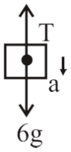


The force balancing equation for 4 kg block,

$T - m_1g = m_1a$

$T - 4g = 4a$ ….(i)

For block B –



Force balancing equation for 6 kg block,

$m_2g - T = m_2a$

$6g - T = 6a$ …(ii)

Adding equation (i) and (ii), we get -

$2g = 10a$

$a = g/5$

397. A body of mass 2 kg is acted upon by two each of magnitude 1 N and inclined at 60^0 with each other. The acceleration of the body in m/s^2 is ($\cos 60^0 = 0.5$)

(a) $\sqrt{0.75}$ (b) $\sqrt{0.35}$
(c) $\sqrt{0.65}$ (d) $\sqrt{0.20}$

MHT-CET 2020

Ans. (a) : Given,

$F_1 = F_2 = 1N$

$m = 2kg$

$\theta = 60^o$

$$\text{Resultant force } F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{1^2 + 1^2 + 2\cos 60^o}$$

$$= \sqrt{2 + 2(0.5)} = \sqrt{3}N$$

$$F = \sqrt{3}$$

$$a = \frac{F}{m}$$

or $$a = \frac{\sqrt{3}}{2} = \sqrt{\frac{3}{4}} = \sqrt{0.75}\ m/s^2$$

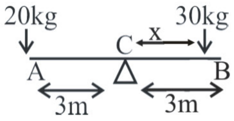
398. A see-saw of length 6 m is pivoted at its centre. A child of mass 20 kg is sitting at one of its ends. Where should another child, of mass 30 kg, sit on the other end from the centre of see-saw, so that it is balanced ?

(a) 1 m (b) 3 m
(c) 2 m (d) 4 m

MHT-CET 2020

Ans. (c) : Let, 'n' be the distance of B from the fulcrum.

$F_1 = 20g$ and $F_2 = 30g$



For equilibrium,

$20 \times 3 = 30 \times x$

$x = \frac{60}{30}$

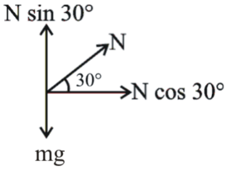
$x = 2m$

399. A cyclist leans with the horizontal at angle 30^o, while negotiating round a circular road of radius $20\sqrt{3}$ m. The speed of the cycle should be

(a) $7\sqrt{3}\ m/s$ (b) $14\ m/s$
(c) $7\sqrt{6}\ m/s$ (d) $10\sqrt{6}\ m/s$

TS-EAMCET.11.09.2020, Shift-2

Ans. (d):



From F.B.D. of cyclist, we have

$N \sin 30^o = mg$ ……(i)

@apna_pdf

and $N\cos 30^\circ = \dfrac{mv^2}{R}$ ....(ii)

dividing equation (i) by (ii)

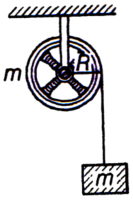
$$\tan 30^\circ = \frac{gR}{v^2} \Rightarrow \frac{1}{\sqrt{3}} = \frac{gR}{v^2}$$

$$v^2 = gR\sqrt{3} = 10\times20\sqrt{3}\times\sqrt{3}$$

$$v = \sqrt{600}$$

$$v = 10\sqrt{6}\,m/s$$

400. A mass *m* is supported by a massless string wound around a uniform hollow cylinder of mass *m* and radius *R*. If the string does not slip on the cylinder, then with what acceleration will the mass release?
(Assume, g = acceleration due to gravity)

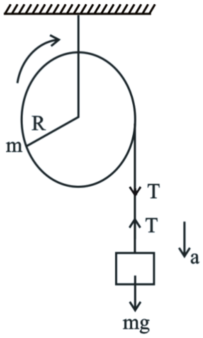


(a) $\dfrac{2g}{3}$ (b) $\dfrac{g}{2}$

(c) $\dfrac{5g}{6}$ (d) g

TS-EAMCET-09.09.2020, Shift-1

Ans. (b) :



From free body diagram, we have

$mg - T = ma.$

As we know,

linear acceleration = radius × angular acceleration

$a = R\alpha$

So, $mg - T = mR\alpha$

$mg - mR\alpha = T$ ...(i)

For pulley, Torque about centre,

$\tau = T\times R = mR^2\alpha$

$T = mR\alpha$ ...(ii)

From equation (i) and (ii),

$mg - mR\alpha = mR\alpha$

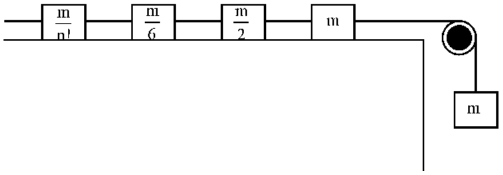
$g = 2R\alpha$

$g = 2R\times\dfrac{a}{R}$

$g = 2a$

$a = g/2$

401. An infinite number of masses are placed on a frictionless table and they are connected via mass less strings. Their masses follow the sequence, m, $\dfrac{m}{2},\dfrac{m}{6},$.........., $\dfrac{m}{n!}$,.......... and they are further connected to a mass m that hangs over a mass less pulley. The acceleration of the hanging mass is



(a) $\dfrac{g}{e-1}$ (b) $\dfrac{g}{e+1}$

(c) $\dfrac{g}{e}$ (d) $\dfrac{g}{2e}$

TS-EAMCET-11.09.2020, Shift-1

Ans. (c) : Effective mass of the system,

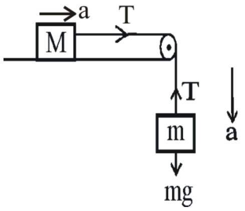
$$M = m + \frac{m}{2} + \frac{m}{6} + \quad ....+\frac{m}{n!}$$

$$= m\left(1+\frac{1}{2!}+\frac{1}{3!}+ \quad ......+\frac{1}{n!}\right)$$

$$= m\left(1+\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+ \quad ....+\frac{1}{n!}-1\right)$$

$$M = m(e-1)\ \left\{\because e = 1+\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+.......+\frac{1}{n!}\right\}$$

Now, the system can be shown as–



Now, from F.B.D.

For upper mass-

$T = Ma,$

$T = m(e-1)\,a$ ......(i)

For hanging mass -

$mg - T = ma$

$T = m(g-a)$ ......(ii)

From equation (i) and (ii) –

$m(e-1)\,a = m(g-a)$

$ae - a = g - a$

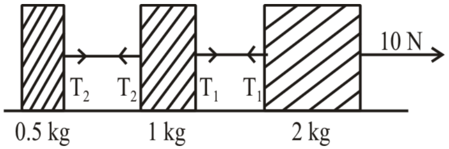
$ae - g = 0$

$ae = g$

$a = \dfrac{g}{e}$

402. Three blocks of masses 2 kg. 1 kg and 0.5 kg are connected by an inextensible string as shown below. A below of 10 N is applied on the body of mass 2 kg. The acceleration of the system and the tensions T_1 and T_2 are

@apna_pdf



(a) 2.86 ms^{-2}, 4.29 N, 1.43 N
(b) 3.00 ms^{-2}, 5.00 N, 6.20 N
(c) 7.25 ms^{-2}, 2.35 N, 3.15 N
(d) 2.00 ms^{-2}, 4.32 N, 8.64 N

Assam CEE-2019

Ans. (a) : Given, $m_1 = 0.5$ kg, $m_2 = 1$ kg, $m_3 = 2$ kg

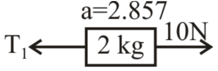
$F = 10$ N

We know that,

$F = ma$

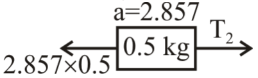
$$a = \frac{F}{m} = \frac{10N}{m_1 + m_2 + m_3} = \frac{10N}{3.5kg} = 2.857\,m/sec^2$$

Free body diagram of 2 kg block,



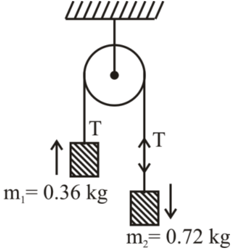
$T_1 + 2.857 \times 2 = 10$ N
$T_1 = 10 - 5.714$
$T_1 = 4.296$ N
$T_1 = 4.29$ N

Free body diagram of 0.5 kg block,



$T_2 = 2.857 \times 0.5$
$T_2 = 1.4285$
$T_2 = 1.43$ N

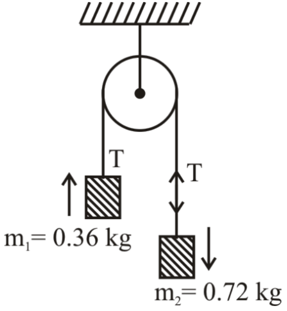
403. In the arrangement shown in the figure, work done by the string on the block of mass 0.36 kg during the first second after the blocks are released from state of rest is (Ignore friction and mass of the string.)
(Acceleration due to gravity, g = 10 ms^{-2})



(a) 8 J
(b) 4 J
(c) 12 J
(d) 2 J

AP EAMCET (22.04.2019) Shift-I

Ans. (a) : According to the question,



Given, mass of block 1 (m_1) = 0.36 kg
mass of block 2 (m_2) = 0.72 kg
and acceleration due to gravity (g) = 10 m/s^2

Now, Dynamic equation of block m_1 ($m_2 > m_1$).

$\therefore\ T - m_1g = m_1a$ ...(i)

Dynamic equation of block m_2 ($m_2 > m_1$).

$\therefore\ m_2g - T = m_2a$ ...(ii)

Thus from adding equation (i) and (ii), we get–

$\therefore\ T - m_1g + m_2g - T = m_1a + m_2a$

$m_2g - m_1g = a(m_1 + m_2)$

$$a = \frac{(m_2 - m_1)g}{(m_1 + m_2)}$$

$$\therefore\quad a = \frac{(0.72 - 0.36)}{1.08} \times 10$$

$$a = \frac{3.6}{1.08}\,m/s^2 \quad ....(iii)$$

Now, the tension force in the string is,
for block 1st, $m_1 = 0.36$ kg

$T - m_1g = m_1a$

$$\frac{T - m_1g}{m_1} = a$$

$$\frac{T - 3.6}{0.36} = \frac{3.6}{1.08}$$

$$T = 3.6 + 0.36 \times \frac{3.6}{1.08}$$

$T = 4.8N$ ...(iv)

Distance travelled by block 1,
By displacement – time relation,

Displacement, $s = ut + \frac{1}{2}at^2$ [$\because u = 0$]

[by kinetic equation for uniformly motion]

$$s = \frac{1}{2} \times \frac{3.6}{1.08} \times (1)^2 \quad [\therefore\ t = 1 \text{ second given }]$$

$$s = \frac{1}{2} \times \frac{3.6}{1.08} = 1.6 \quad ...(v)$$

Now, work done by the string on the block of mass (m_1) is 0.36 kg.

$\therefore$ Work done (W) = Tension force (T)×displacement (s)

$W = T \times s$

From equation (iv) and (v), we get–

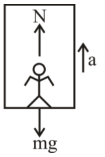
$W = 4.8 \times 1.6 = 7.68\ J \approx 8\ J$

404. A lift is moving up with an acceleration equal to 1/5 of that due to gravity. The apparent weight of a 60kg man standing in lift is:

(a) 60 kg wt
(b) 72 kg wt
(c) 48 kg wt
(d) Zero

SRMJEE-2019

Ans. (b) : The acceleration of lift = $\frac{g}{5}$



@apna_pdf

When lift is accelerating upwards, The equation of motion is,

$$ma = N - mg$$
$$N = ma + mg$$
$$N = m(a + g)$$
$$N = m(g/5 + g)$$
$$= \frac{60 \times 6 \times g}{5} = \frac{60 \times 6 \times 10}{5}$$
$$= 720 \text{ N or } 72 \text{ kg wt.}$$

405. Two masses m_1 and m_2 are connected by a massless string over a fixed pulley. If $m_1 > m_2$, m_1 will move downward and m_2 will move upward. What is the acceleration with which the combination of two masses will move? (g = acceleration due to gravity)

(a) 0

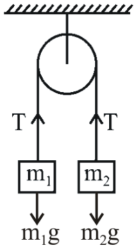
(b) g

(c) $[(m_1 - m_2)/(m_1 + m_2)] \times g$

(d) $[2m_1m_2/(m_1 + m_2)] \times g$

J&K-CET-2019

Ans. (c) :



Let, the acceleration of both blocks = 'a'

So, from equation of motion;

$$m_1g - T = m_1a$$
$$T - m_2g = m_2a \qquad (\text{If } m_1 > m_2)$$

If we eliminate 'T' then we get;

$$a = \frac{m_1 - m_2}{m_1 + m_2} g \qquad \text{.... (i)}$$

again, acceleration of center of mass

$$a_{cm} = \frac{m_1a_1 - m_2a_2}{m_1 + m_2}$$

Here, $\vec{a}_1 = a$

$\vec{a}_2 = -a$

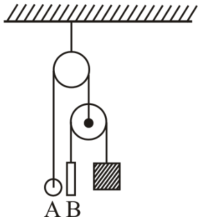
So, if m_1 moves down, m_2 moves up

$$a_{cm} = \frac{(m_1 - m_2)a}{m_1 + m_2} \qquad \text{....(ii)}$$

We get,

$$a_{cm} = \frac{(m_1 - m_2)}{(m_1 + m_2)} g$$

406. In the pulley system shown in the figure, the mass of A is half of that of rod B. The rod length is 500 cm. The mass of pulleys and the threads may be neglected. The mass A is set at the same level as the lower end of the rod and then released. After releasing the mass A, it would reach the top end of the rod B in time (Assume, g = 10 m/s^2)



(a) 2.0 s

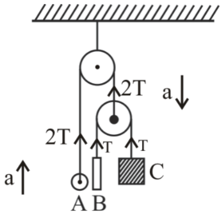
(b) 1.0 s

(c) 3.0 s

(d) 4.0 s

TS-EAMCET-04.05.2019, Shift-2

Ans. (b) : Let mass of body A, B and C are M_A, M_B and M_C.



According to question,

Mass of A is half of that of rod B.

$$\Rightarrow M_A = \frac{M_B}{2} \Rightarrow 2M_A = M_B, \quad g = 10 ms^{-1}$$

Length of rod = 500cm or 5m

Since, rod B and body C is in equilibrium,

So, $M_B = M_C$

Newton's law of motion,

$$2T - M_Ag = M_Aa \qquad \text{....(i)}$$
$$2M_Bg - 2T = 2M_Ba$$
$$[M_A = M_B + M_C, \ \because M_B = M_C]$$
$$4M_Ag - 2T = 4M_Aa \qquad \text{....(ii)}$$

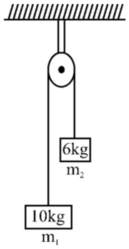
Adding equation (i) & (ii)

$$4M_Ag - M_Ag = M_Aa + 4M_Aa$$
$$3M_Ag = 5M_Aa$$
$$\Rightarrow \quad a = \frac{3}{5}g = \frac{3 \times 10}{5} \Rightarrow 6 m/s^2$$

Applying law of second equation of motion,

$$s = ut + \frac{1}{2}at^2$$
$$s = 0 + \frac{1}{2}at^2$$
$$t = \sqrt{\frac{2 \times s}{a}} = \sqrt{\frac{2 \times 5}{6}} = 1.28 \approx 1s$$

407. Two masses m_1 and m_2 are attached to a string which passes over a frictionless smooth pulley. When m_1= 10 kg, m_2 =6 kg, the acceleration of masses is

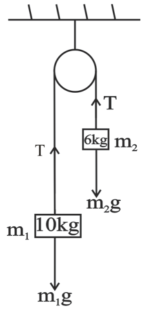


@apna_pdf

(a) 20 m/s^2 (b) 5 m/s^2
(c) 2.5 m/s^2 (d) 10 m/s^2

Manipal UGET-2019

Ans. (c) :



From F.B.D. we have,

$m_1g - T = m_1a$ ……(i)

and $T - m_2g = m_2a$ ……(ii)

From eq^n (i) be (ii), we get,

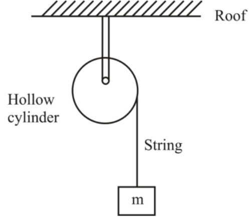
$$m_1g - m_2g = (m_1+m_2)\,a$$

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

$$= \frac{(10-6)10}{(10+6)} = \frac{40}{16}$$

$$a = 2.5\,m/s^2$$

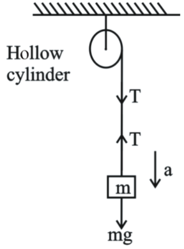
408. In the figure shown, acceleration with which the mass m falls down when released is (consider the string to be massless, g-acceleration due to gravity)



(a) $\frac{2g}{3}$ (b) $\frac{g}{2}$
(c) $\frac{5g}{6}$ (d) g

AP EAMCET (20.04.2019) Shift-1

Ans. (b) : Let m be the mass & 'R' be the radius of hollow cylinder.



When the system is released, torque produced in hollow cylinder is

$$\tau = I\alpha,$$

$$= MR^2 . \frac{a}{R} \qquad \{\because I = MR^2 \;\&\; a = \alpha R\}$$

$\tau = MR\,a$ ……(i)

Also, we know $\tau = FR = TR$ ……(ii)

Equating (i) & (ii) we get

$TR = M.R\,a.$

$T = Ma$ …….(iii)

Now, from F.B.D.

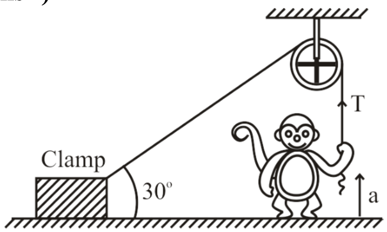
$Mg - T = Ma$

$Mg - Ma = Ma$ {using eq^n. (iii)}

$g = 2a$

$$a = \frac{g}{2}$$

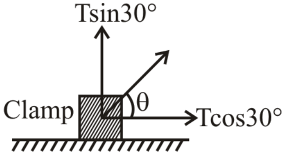
409. One end of a light string is fixed to a clamp on the ground and the other end passes over a fixed frictionless pulley as shown in the figure. It makes an angle of 30° with the ground. The clamp can tolerate a vertical force of 40 N. If a monkey of mass 5 kg were to climb up the rope, then the maximum acceleration in the upward direction with which it can climb safely is ($g = 10\ ms^{-2}$)



(a) 2 ms^{-2} (b) 4 ms^{-2}
(c) 6 ms^{-2} (d) 8 ms^{-2}

AP EAMCET (20.04.2019) Shift-1

Ans. (c) : Let 'T' be the tension in the string and 'a' be the acceleration in the upward direction.



The upward force created on damp is,

$$T \sin 30^\circ = \frac{T}{2}$$

$\frac{T}{2} = 40N$ (Given)

$T = 80\ N$ …….(i)

Now, for monkey to climb up,

$$T - mg = ma$$

$$a = \frac{T - mg}{m}$$

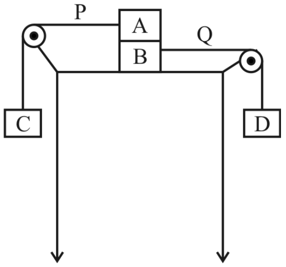
$$= \frac{80 - 5\times 10}{5}$$

$$a = 6m/s^2$$

410. Four blocks A, B, C and D of masses 6 kg, 3 kg, 6 kg and 1 kg respectively are connected by light strings passing over frictionless pulleys as shown in the figure. The strings P and Q are horizontal. The coefficient of friction between the horizontal surface and the block B is 0.2 and the blocks A and B move together. If the system is released from rest.

@apna_pdf

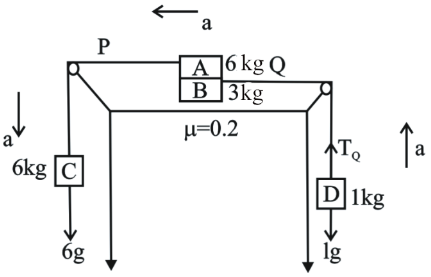
Then the tension in the string Q is (Acceleration due to gravity, $g = 10\ ms^{-2}$)



(a) 48 N (b) 24 N
(c) 12 N (d) 6 N

AP EAMCET (23.04.2019) Shift-I

Ans. (c) :



From F.B.D. we have,

$T_Q - 1g = 1 \times a$

$T_Q = a + g$ ……..(i)

$(m_A + m_B + m_C + m_D)\ a = m_C g - m_D g - f_s$

$$a = \frac{\left[m_C - m_D - \mu\left(m_A + m_B\right)\right]}{m_A + m_B + m_C + m_D} g \quad \left\{\because f_s = \mu\left(m_A + m_B\right)g\right\}$$

$$a = \frac{\left[6 - 1 - 0.2 \times 9\right]}{6 + 3 + 6 + 1} \times 10$$

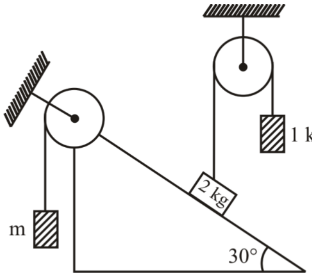
$$= \frac{32}{16}$$

$a = 2\ m/s^2$

$$T_Q = 1kg \times \frac{2m}{s^2} + 1kg \times 10 \frac{m}{s^2}$$

$= 12\ kg\ m/s^2 = 12\ N$

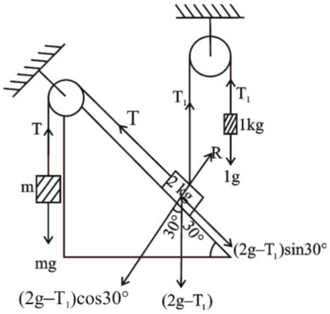
411. A system containing masses and pulleys connected on an inclined plane is shown in the figure. If the system is in equilibrium then the value of m is



(a) 1 kg (b) 0.5 kg
(c) 0.75 kg (d) 0.25 kg

AP EAMCET (22.04.2019) Shift-I

Ans. (b) :



From the F.B.D. we have –
Since the system is in equilibrium.

$T = mg$ ……(i)

$T = (2g - T_1) \sin 30°$ ……(ii)

$T_1 = g$ ……(iii)

From eq^n. (ii) & (iii) we have

$$T = (2g - g) \sin 30° = \frac{g}{2} \quad \text{…….(iv)}$$

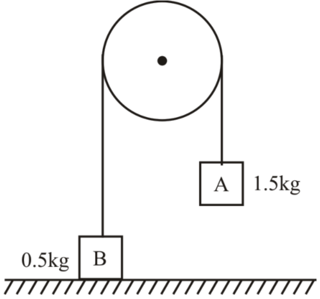
From eq^n. (i) & (iv), we get

$$\frac{g}{2} = mg$$

$$m = \frac{1}{2}\ kg$$

$m = 0.5$ kg

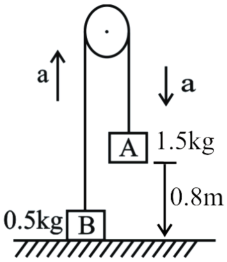
412. Two block A and B of masses 1.5 kg and 0.5 kg, respectively are connected by a massless inextensible string passing over a frictionless pulley as shown in the figure. Block A is lifted until block B touches the ground and then block A is released. The initial height of block A is 80 cm when block B just touches the ground. The maximum height reached by block B from the ground after the block A falls on the ground is



(a) 80 cm (b) 120 cm
(c) 140 cm (d) 160 cm

AP EAMCET (21.04.2019) Shift-II

Ans. (b) :



@apna_pdf

From F.B.D. of the system, the common acceleration of two masses,

$$a=\left(\frac{m_A-m_B}{m_A+m_B}\right)g$$

$$=\left(\frac{1.5-0.5}{1.5+0.5}\right)10$$

$$a = 5\text{m/s}^2$$

When block A is released,

$v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 10h$

$v^2 = 20h.$

But for height 0.8m, block A falls with common acceleration, therefore from third eq^n. of motion,

$$v_1^2 = u_1^2 - 2a\times 0.8 \qquad .....(i)$$

Hence, $v_1 = 0,\ u_1^2 = v^2 = 20h.$

$0 = 20\times h - 2\times5\times0.8 \qquad (\because\ a = 5\ \text{m/s}^2)$

$20h = 8$

$h = 0.4\text{m} = 40$ cm.

Therefore, maximum height reached by block B

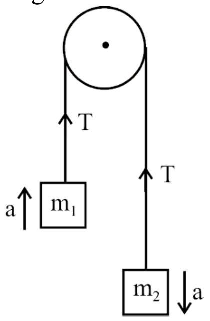
= 80 + 40 = 120 cm

413. Two blocks of masses 'm_1' and 'm_2' are suspended by a massless string passing over a smooth pulley, if the acceleration of the system is $\frac{g}{8}$ then the ratio of the masses $\frac{m_2}{m_1}=$

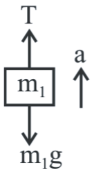
(a) 8 : 1
(b) 8 : 7
(c) 9 : 7
(d) 4 : 3

AP EAMCET-25.04.2018, Shift-I

Ans. (c) : Given, a = g/8

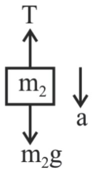


FBD for block m_1,



$T = m_1a + m_1g \qquad \ldots(i)$

FBD for block m_2,



$T = m_2g - m_2a \qquad \ldots(ii)$

From equation (i) & (ii), we get–

$m_2g - m_1g = m_2a + m_1a$

$g(m_2 - m_1) = a(m_2 + m_1)$

$$a=\frac{(m_2-m_1)g}{m_2+m_1}$$

$$\frac{g}{8}=\frac{(m_2-m_1)g}{m_2+m_1}$$

$$\frac{1}{8}=\frac{m_2-m_1}{m_2+m_1}$$

$m_2 + m_1 = 8m_2 - 8m_1$

$9m_1 = 7m_2$

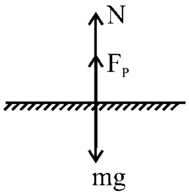
$$\frac{m_2}{m_1}=\frac{9}{7}$$

414. A man weighing 60 kg is in lift moving down with an acceleration of 1.8 ms^{-2}. The force exerted by the floor on him is :

(a) 588 N
(b) 480 N
(c) zero
(d) 696 N

Karnataka CET-2018

Ans. (b) :



Given that,

Acceleration (a) = 1.8m/s^2

mass (m) = 60 kg

Now,

$N + F_P = mg$

$N + ma = mg \qquad (\because F_P = m\times a)$

Then,

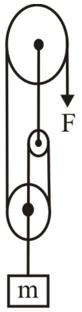
Normal(N) = mg – ma

= m (g–a)

= 60×(9.8–1.8)

= 480N

415. If the block moves up with constant velocity v m/s, then find F.



(a) $F=\frac{mg}{2}$
(b) $F=\frac{2mg}{3}$
(c) $F=\frac{mg}{3}$
(d) $F=\frac{5mg}{3}$

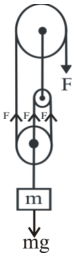
AIIMS-26.05.2018(E)

@apna_pdf

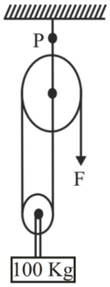
Ans. (c) : Since the block is moving with constant velocity thus, the net force acting on the block will be zero. So, the tension in the wire will be balanced by weight

$3F = mg$

$F = mg/3$



416. In the given diagram, 100 kg block is moving up with constant velocity, then find out the tension at point P:

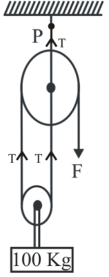


(a) 1980 N (b) 1560 N

(c) 1380 N (d) 1470 N

AIIMS-26.05.2018(M)

Ans. (d) : F.B.D. for given system,



From balance equation

$2T = mg$

$$T = \frac{100\times g}{2} = 50g$$

At P, tension = 3T

$= 3 \times 50\ g$

$= 150\ g$

$= 150 \times 9.8$

$= 1470$ N

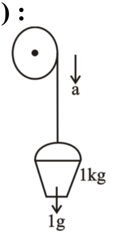
417. An empty bucket of mass 1 kg attached by a light cord passed over a pulley of a water well is released form rest. If the pulley assembly is assumed to be a uniform solid cylinder of mass 8 kg and free to rotate about its axis without any friction, then the speed of the bucket as it hits the water 16 m below is (take, g = 10 ms^{-2})

(a) 4 ms^{-1} (b) 8 ms^{-1}

(c) 16 ms^{-1} (d) 20 ms^{-1}

AP EAMCET (23.04.2018) Shift-2

Ans. (b) :



Torque acting on pulley, $\tau = I\ \alpha$

Let m be the mass and 'r' be the radius of the pulley.

$$\tau = \frac{mr^2}{2}\alpha$$

Now, from F.B.D. $\frac{mr^2}{2}.\alpha = mgr$

$$\frac{mr^2}{2}.\alpha = 1\times gr$$

$$\alpha = \frac{2g}{mr}$$

So, acceleration of rope, $a = r\alpha$

$$a = \frac{2}{mr}g.r = \frac{2g}{m}$$

$$= \frac{2\times 10}{8}$$

$$a = 2.5\ m/s^2$$

As given, s = 16 m ; u = 0

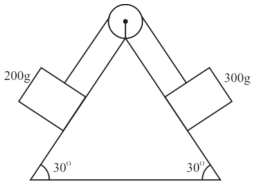
And we know, $v^2 = u^2 + 2as$

$v^2 = 0 + 2\times2.5\times16$

$v = 4\sqrt{5} = 4\times2.236 = 8.944$

$v = 8m/s$ {Absolute value}

418. A double inclined plane as shown in the figure has fixed horizontal base and smooth faces with the same angle of inclination of 30o. A block of mass 300 g is on one face and is connected by a cord passing over a frictionless pulley to a second block of mass 200 g kept on another face. The acceleration with which the system of the blocks moves is ……% of acceleration due to gravity.

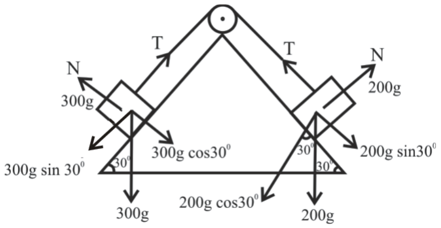


(a) 5 (b) 10

(c) 15 (d) 20

AP EAMCET (22.04.2018) Shift-II

Ans. (b) : According to the question, the free body diagram is –



@apna_pdf

$300\text{ g}\sin 30^\circ - T = 300a$ ......(i)

and $T - 200\text{ g}\sin 30^\circ = 200\text{ a}$ ......(ii)

Eq^n. (i) + Eq^n. (ii)–

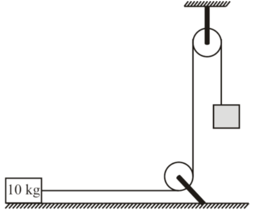
$$100\text{ g}\sin 30^\circ = 500\text{ a}$$

$$50\text{ g} = 500\text{ a}$$

$$a = \frac{1}{10}g$$

$$\boxed{a = 10\% \text{ of g}}$$

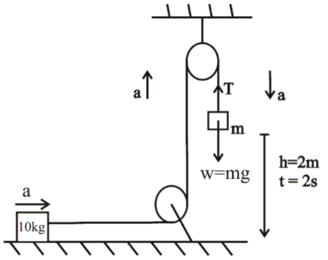
419. A block of mass 10 kg is placed on a horizontal frictionless surface and is attached to a cord which passes over two light frictionless pulleys as shown in the figure. The hanging block tied to the other end of the cord is initially at rest 2 m above the horizontal floor. If the hanging block strikes the floor 2 s after the system is released, then weight of the hanging block is …… ($g = 10\text{ ms}^{-2}$)



(a) 22.22 N (b) 11.11 N
(c) 1.11 N (d) 2.22 N

AP EAMCET (22.04.2018) Shift-II

Ans. (b) : Let 'm' be the mass of hanging body.



When the system released, the hanging block strikes the floor after 2s, then–

$$h = ut + \frac{1}{2}at^2$$

$$2 = 0 + \frac{1}{2}a(2)^2$$

$$\boxed{a = 1\text{ m/s}^2}$$

Now, $T = 10\times a = 10\times 1 = 10\text{ N}$ {for 10 kg block}

$ma = mg - T$ {for m kg block}

$$T = m(g - a)$$

$$10 = m(10 - 1)$$

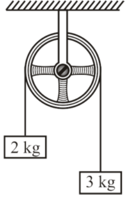
$$m = \frac{10}{9}$$

Now, weight (w) = mg

$$= \frac{10}{9}\times 10 = \frac{100}{9}$$

$$\boxed{W = 11.11\text{N}}$$

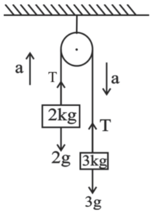
420. The system of two masses 2 kg and 3 kg as shown in the figure is released from rest. The work done on 3 kg block by the force of gravity during first 2 seconds of its motion is ($g = 10\text{ ms}^{-2}$)



(a) 120 J (b) 80 J
(c) 40 J (d) 30 J

AP EAMCET (22.04.2018) Shift-1

Ans. (a) : The F.B.D. of the system is –



From F.B.D. we have-

$3g - T = 3a$ ....(i)

$T - 2g = 2a$ ......(ii)

From eq^n. (i) & (ii)–

$$g = 5a$$

$$a = \frac{10}{5} = 2\text{m/s}^2$$

When the system is released distance covered by 3kg block during first 2 sec is–

$$h = ut + \frac{1}{2}at^2$$

$$h = 0\times 2 + \frac{1}{2}\times 2\times (2)^2$$

$$h = 4\text{m}.$$

Now, work done = mgh

$$= 3\times 10\times 4$$

$$W = 120\text{ J}$$

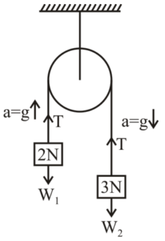
421. Two weights 2 N and 3 N are suspended from the ends of an inextensible string passing over a fixed frictionless pulley. If the pulley is pulled up with an acceleration equal to the acceleration due to gravity, then the tension in the string is

(a) 2.4 N (b) 5.0 N
(c) 4.8 N (d) 6.0 N

AP EAMCET-25.04.2017, Shift-II

Ans. (c) : Given that, $W_1 = 2\text{N}$, $W_2 = 3\text{N}$

In this type of system when two weights are suspended from the ends of light spring passing through smooth fixed pulley,



@apna_pdf

The tension is given by–

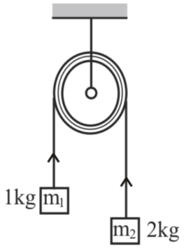
$$T = \frac{4W_1W_2}{W_1 + W_2}$$

Putting the value of W_1 and W_2,

$$T = \frac{4\times2\times3}{2+3}$$

$$T = 4.8\text{ N}$$

422. Two masses m_1 = 1 kg and m_2 = 2 kg are connected by a light inextensible string and suspended by means of a weightless pulley as shown in the figure.



Assuming that both the masses start from rest, the distance travelled by the centre of mass in 2s is (Take g = 10 ms^{-2})

(a) $\frac{20}{9}$m (b) $\frac{40}{9}$m

(c) $\frac{2}{3}$m (d) $\frac{1}{3}$m

(e) 4 m

Kerala CEE - 2011

Ans. (a) : Given m_1 = 1 kg, m_2 = 2 kg, g = 10 ms^{-2}

$$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)g$$

$$= \left(\frac{2-1}{1+2}\right)10 = \frac{10}{3}$$

Acceleration of centre of mass is

$$a_{cm} = \frac{m_1a + m_2a}{m_1 + m_2}$$

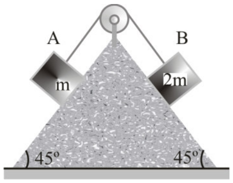
$$= \frac{1(-a)+2(a)}{1+2}$$

$$= \frac{a}{3} = \frac{10}{9}$$

The distance travelled by the centre of mass in 2 sec is

$$S = \frac{1}{2}a_{cm}t^2 = \frac{1}{2}\times\frac{10}{9}\times(2)^2 = \frac{20}{9}\text{m}$$

423. Block A of mass m and block B of mass 2m are placed on a fixed triangular wedge by means of a massless, inextensible string and a frictionless pulley as shown in figure. The wedge is inclined at 45° to the horizontal on both the sides. If the coefficient of friction between the block A and the wedge is 2/3 and that between the block B and the wedge is 1/3 and both the blocks A and B are released from rest, the acceleration of A will be

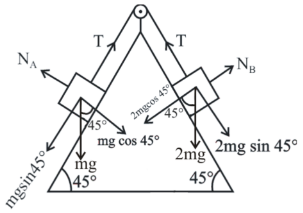


(a) -1 (b) 1.2

(c) 0.2 (d) zero

UPSEE - 2008

Ans. (d) :



$$2mg\sin45° - mg\sin45° = F$$

$$\frac{2mg}{\sqrt2} - \frac{mg}{\sqrt2} = F$$

$$F = \frac{mg}{\sqrt2} = 0.707\text{ mg} \quad \text{......(i)}$$

Friction force, $f = f_A + f_B = \mu_AN_A + \mu_BN_B$

$$= \mu_A\,mg\cos45° + \mu_B\,2mg\cos45°$$

$$= \frac{2}{3}\times\frac{mg}{\sqrt2} + \frac{1}{3}\times\frac{2mg}{\sqrt2}$$

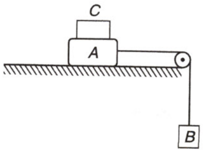
$$\text{Friction force } = \frac{4mg}{3\sqrt2} = 0.942\text{ mg} \quad \text{......(ii)}$$

Friction force > Tension is Rope

from eq^n. (i) & (ii) it is clear that magnitude of force of friction is greater that cause A & B to move but the mass system will not move.

Therefore, the acceleration of system will be zero.

424. Two masses A and B of 15 kg and 10 kg are connected with a string passing over a frictionless pulley fixed at the corner of a table (as shown in figure). The coefficient of friction between the table and block is 0.4. The minimum mass of C, that may be placed on A to prevent it from moving is :

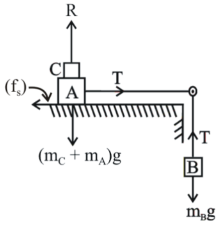


(a) 10 kg (b) 5 kg

(c) zero (d) 15 kg

UPSEE - 2005

Ans. (a) :



@apna_pdf

Let m_c be the mass of block C and f_s be mass static friction.

From free body diagram we have,

For block A, $R = (m_A + m_C)g$ and $f_S = T$

$$\mu (m_A + m_C)g = T \qquad \text{.......(i)}$$

For block B,

$$T = m_B g \qquad \text{.......(ii)}$$

From eq^n. (i) & (ii) we have,

$$\mu(m_A + m_C)g = m_B g$$

$$m_C = \frac{m_B - \mu m_A}{\mu}$$

$$= \frac{10 - 0.4 \times 15}{0.4}$$

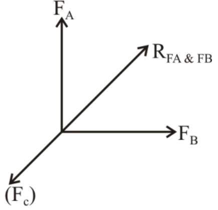
$$\boxed{m_C = 10\text{kg}}$$

425. Which of the following groups of forces could be in equilibrium?

(a) 3N, 4 N, 5 N
(b) 4N, 5 N, 10 N
(c) 30 N, 40 N, 80 N
(d) 1N, 3 N, 5 N

UPSEE - 2004

Ans. (a) : For equilibrium of forces, the resultant of two smaller forces should be equal and opposite to third one.



Therefore, the resultant force of F_A and F_B is equal to $R_{FA\,\&\,FB}$ which is equal to (F_C) in opposite direction.

$$F_C^2 = F_A^2 + F_B^2$$

$$(5)^2 = (3)^2 + (4)^2$$

$$25 = 25$$

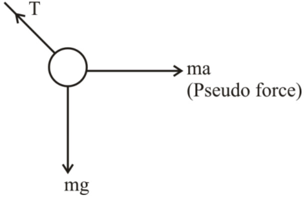
426. Inside a horizontally moving box, an experimenter finds that when an object is placed on a smooth horizontal table and is released, it moves with an acceleration of 10 m/s^2. In this box if 1 kg body is suspended with a light string. The tension in the string in equilibrium position (w.r.t. experimenter) will be (Take g = 10 m/s^2)

(a) 10 N
(b) $10\sqrt{2}$N
(c) 20 N
(d) zero

BITSAT-2005

Ans. (b) Since, the object slides with acceleration 10 m/s^2 and the acceleration of box is $10 m/s^2$.

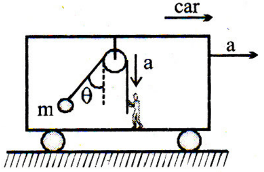
Inside the box a body suspended experiences a pseudo force.



$$T = \sqrt{(mg)^2 + (ma)^2} = \sqrt{(1 \times 10)^2 + (1 \times 10)^2}$$

$$= \sqrt{100 + 100} = \sqrt{200} = 10\sqrt{2}\text{ N}$$

427. A bob is hanging over a pulley inside a car through a string. The second end of the string is in the hand of a person standing in the car. The car is moving with constant acceleration 'a' directed horizontally as shown in figure. Other end of the string is pulled with constant acceleration 'a' vertically. The tension in the string is equal to –

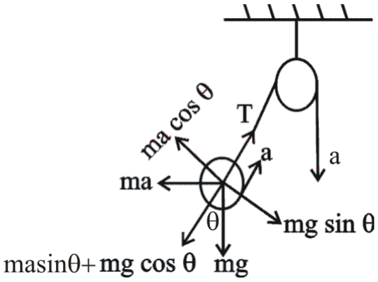


(a) $m\sqrt{g^2 + a^2}$
(b) $m\sqrt{g^2 + a^2} - ma$
(c) $m\sqrt{g^2 + a^2} + ma$
(d) $m(g + a)$

BITSAT-2013

Ans. (c) : Using the concept of pseudo force in the frame of the car, we have

We make the F.B.D. of given figure,



Force perpendicular to string

$$ma\cos\theta = mg\sin\theta$$

$$\tan\theta = \frac{a}{g}$$

Net force along string

$$T - ma\sin\theta - mg\cos\theta = ma$$

$$T = ma\left(\frac{a}{\sqrt{a^2 + g^2}}\right) + mg\frac{g}{\sqrt{a^2 + g^2}} + ma$$

$$= m\frac{(a^2 + g^2)}{\sqrt{a^2 + g^2}} + ma$$

$$T = m\sqrt{g^2 + a^2} + ma$$

428. Work done in time t on a body of mass m. which is accelerated from rest to speed v in time t_1, as a function of time t, is given by

(a) $\frac{1}{2}m\frac{v}{t_1}t^2$
(b) $m\frac{v}{t_1}t^2$
(c) $\frac{1}{2}\left(\frac{mv}{t_1}\right)^2 t^2$
(d) $\frac{1}{2}m\frac{v^2}{t_1^2}t^2$

CG PET- 2010

Ans. (d) : Since we know that,

$$F = ma$$

$$v = u + at_1$$

@apna_pdf

$$a = \frac{v}{t_1}$$

and $$s = \frac{1}{2}at^2 \qquad \{\because u = 0\}$$

Work done = Force × displacement

$$\therefore W = ma \times \frac{1}{2}at^2$$

$$= \frac{1}{2}ma^2t^2$$

$$= \frac{1}{2}m\left(\frac{v}{t_1}\right)^2 \cdot t^2 \qquad \left[\therefore a = \frac{v}{t_1}\right]$$

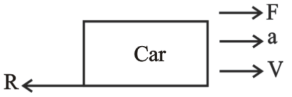
$$W = \frac{1}{2}m\frac{v^2}{t_1^2}t^2$$

429. A car of mass m is driven with an acceleration a along a straight level road against a constant external resistive force R. When the velocity of the car is v, the rate at which engine of the car is doing work will be

(a) R.v (b) ma.v
(c) (R + ma).v (d) (ma–R).v

CG PET- 2009

Ans. (c) :



The engine has to do work against resistive force R as well as car is moving with acceleration a.

From diagram, we have

$$F - R = ma$$

$$F = R + ma$$

We know that,

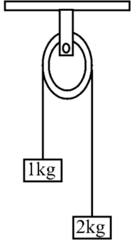
$$P = \frac{w}{t} = \frac{F \times d}{t} = F \times v$$

Where, P = Power, w = work done, t = time, f = force, d = displacement, v = velocity

Rate of doing work = Power = Force × velocity

$$= (R + ma)\,v$$

430. Two unequal masses are connected on two sides of a light string passing over a light and smooth pulley as shown in the figure. The system is released from the rest. The larger mass is stopped for a moment, 1s after the system is set into motion and then released immediately. The time elapsed before the strings is tight again is



(a) 1/4 s (b) 1/2 s
(c) 2/3 s (d) 1/3 s

Manipal UGET-2015

Ans. (d) : We know that the acceleration of the system,

$$a = \frac{(m_1 - m_2)}{m_1 + m_2}g$$

$$a = \frac{(2-1)}{2+1}g = \frac{g}{3}$$

Now, velocity of 1 kg box,

$$v = u + at \quad = 0 + \frac{g}{3} \times 1$$

$$v = \frac{g}{3}$$

(here, we take t = 1 according to question)

$$d_1 = vt_1$$

The displacement of both boxes are equal in magnitude.

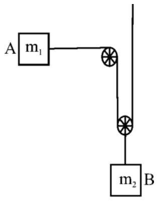
$$d_1 = d_2$$

$$\frac{g}{3}t_1 - \frac{1}{2}gt_1^2 = \frac{1}{2}gt_1^2$$

$$\frac{1}{3} = \frac{1}{2}t_1 + \frac{1}{2}t_1$$

$$t_1 = \frac{1}{3}\text{sec}$$

431. The acceleration of block B in the figure will be

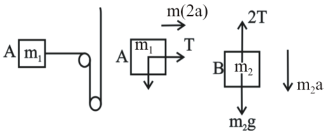


(a) $\dfrac{m_2g}{(4m_1 + m_2)}$ (b) $\dfrac{2m_2g}{(4m_1 + m_2)}$

(c) $\dfrac{2m_1g}{(m_1 + 4m_2)}$ (d) $\dfrac{2m_1g}{(m_1 + m_2)}$

Manipal UGET-2014
UPCPMT-2014

Ans. (a) :



From F.B.D. block ‘m_2’↓move downward with acceleration ‘a’ As block A covers double distance in comparison to block B, there for of B has acceleration 'a', A moved with acceleration 2a.

Now Acceleration of mass ‘m_1’ would be ‘2a’

From F.B.D. of block ‘A’ and ‘B’ we have

$T = m_1\,2a$ ……(i)

$m_2g - 2T = m_2a$ ……(ii)

From eq^n (i) and (ii) [putting the value of T in equation (ii)]

$m_2g - 4m_1a = m_2a$

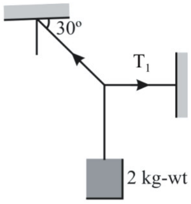
$m_2g = m_2a + 4m_1a$

$m_2g = a(m_2 + 4m_1)$

$$\therefore a = \frac{m_2g}{4m_1 + m_2}$$

@apna_pdf

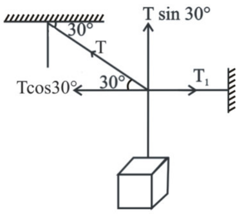
432. A body of weight 2 kg is suspended as shown in figure. The tension T_1 in the horizontal string (in kg-wt) is



(a) $2/\sqrt{3}$
(b) $\sqrt{3}/2$
(c) $2\sqrt{3}$
(d) 2

Manipal UGET-2010

Ans. (c) :



From F.B.D. we have

$T \sin 30^o = 2$ kg-wt.

$$T\times\frac{1}{2} = 2\text{kg-wt}$$

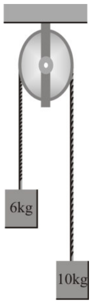
T = 4kg-wt

and $T_1 = T \cos 30°$

$$= \frac{4\sqrt{3}}{2}\text{kg-wt}$$

$$T_1 = 2\sqrt{3}\text{kg-wt}$$

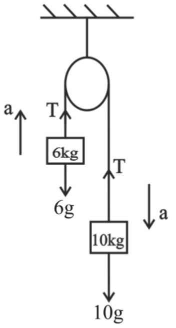
433. The tension in the string in the pulley system shown in the figure is



(a) 75 N
(b) 80 N
(c) 7.5 N
(d) 30 N

Manipal UGET-2010

Ans. (a) :



From, F.B.D. we have,

$T - 6g = 6a$ ……(i)

$10g - T = 10a$ ……(ii)

Adding Eq^n. (i) from (ii), we get

$4g = 16a$

$$a = \frac{g}{4}$$

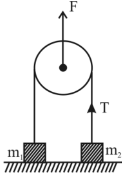
Putting the value of a in equation (i), we get –

$$T = \frac{6g}{4} + 6g = 10\left(\frac{3}{2}+6\right)$$

$$\boxed{T = 75\text{N}}$$

434. Two blocks are resting on ground with masses m_1 and m_2. A string connects them which goes over a mass less pulley P. There is no friction between pulley and string. As force F is applied on pulley P. The acceleration of centre of mass of blocks is

(Given that $T = 2\, m_1\, g$ and $m_2 = 3\, m_1$)



(a) g/8
(b) g/4
(c) $\frac{g}{2}$
(d) g

JCECE-2015

Ans. (b) : Given that,

$T = 2m_1g$

$m_2 = 3m_1$

For m_2 acceleration, $a_2 = 0$ because m_2 will not be lifted because it is heavier than m_1

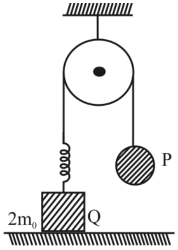
For $m_1, T - m_1g = m_1a_1$

$$\Rightarrow \quad a_1 = \frac{2m_1g - m_1g}{m_1} = g \quad (\because\ T = m_2g = 2m_1g)$$

$$\text{Acceleration of centre of mass } (a_{cm}) = \frac{m_1a_1 + m_2a_2}{m_1+m_2}$$

$$= \frac{m_1a_1 + 0}{m_1+m_2} = \frac{m_1g}{m_1+3m_1} = \frac{g}{4}$$

435. In the figure, the ball P is released from rest, when the spring is at its natural length. For the block Q of mass $2m_0$ to leave contact with ground at some stage, the minimum mass of P must be



(a) m_0
(b) $2m_0$
(c) $m_0/2$
(d) $m_0/4$

JCECE-2015

@apna_pdf

Ans. (a) : According to question,
Mass of Q = $2m_o$
If mass P move to a distance x, then spring will stretch to x value. And it will lift the mass Q

Force in spring, $F = kx = 2m_og$ .....(i)

$$KE = PE$$

$$\Rightarrow \quad \frac{1}{2}kx^2 = mgx$$

$$kx = 2mg \quad .....(ii)$$

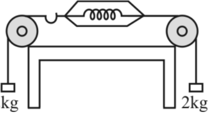
From equation (i) & (ii)

$$2mg = 2m_og$$

$$m = m_o$$

Required mass of P is m, to lift Q.

436. Two equal masses each of 2 kg are suspended from a spring balance as shown in figure. The reading of the spring balance will be



(a) Zero (b) 2 kg
(c) 4 kg (d) between zero and 2 kg

JCECE-2012

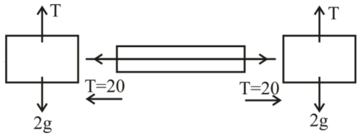
Ans. (b) : According to question,
Two masses of m = 2kg (each)

$$T = \text{Tension}$$

$$T = 2g$$

$$= 2 \times 10$$

$$= 20\text{ N}$$



By balancing the forces, we get, T = 20N
Now,

$$T = mg$$

$$20 = m \times 10$$

$$m = 2\text{kg}$$

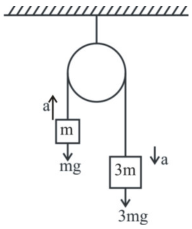
Hence, the reading of spring balance will be 2 kg

437. A pulley fixed to the ceiling carries a string with blocks of masses m and 3m attached to its ends. The masses of string and pulley are negligible. When the system is released, the acceleration of centre of mass will be

(a) Zero (b) $-\frac{g}{4}$
(c) $\frac{g}{2}$ (d) $-\frac{g}{2}$

JCECE-2010

Ans. (b) :



According to Newton's second law,

$$a_{net} = \frac{f_{net}}{\text{Total mass}} = \frac{3mg - mg}{4m} \Rightarrow \frac{2mg}{4m}$$

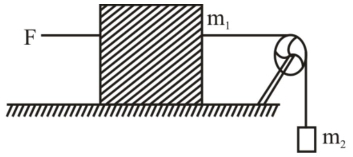
$$a = \frac{g}{2}\text{ms}^{-2}$$

So,
Acceleration of Center of mass,
Upward Acceleration = +ve
Downward Acceleration = –ve
Acceleration of center of mass is given by,

$$a_{cm} = \frac{\sum ma}{\sum m} = \frac{3(m)\left(-\frac{g}{2}\right) + m\left(\frac{g}{2}\right)}{4m}$$

$$a_{cm} = \frac{\frac{-3mg}{2} + \frac{mg}{2}}{4m} = \frac{\frac{-2mg}{2}}{4m} \Rightarrow -\frac{g}{4}$$

438. A constant force F = $m_2g/2$ is applied on the block of mass m_1 as shown in fig. The string and the pulley are light and the surface of the table is smooth. The acceleration of m_1 is



(a) $\frac{m_2g}{2(m_1+m_2)}$ towards right

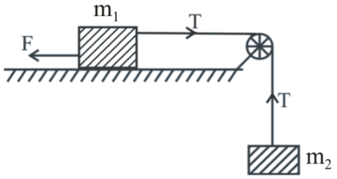
(b) $\frac{m_2g}{2(m_1-m_2)}$ towards left

(c) $\frac{m_2g}{2(m_2-m_1)}$ towards right

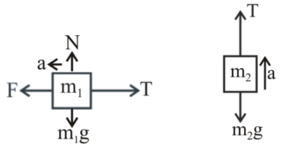
(d) $\frac{m_2g}{2(m_2+m_1)}$ towards left

AIIMS-2015

Ans. (c) :



FBD of the blocks,



From free body diagram,
Let m_1 has an acceleration towards left and m_2 will have an acceleration upwards. Then,

$$F–T = m_2\,a$$

$$\frac{m_2g}{2} - T = m_2a \quad ....(i)$$

and $\quad T – m_2g = m_1a \quad ...(ii)$

@apna_pdf

On adding equation (i) & (ii), we get

$$\frac{m_2g}{2}-m_2g=(m_1+m_2)a$$

$$-\frac{m_2g}{2}=\left(m_1+m_2\right)a$$

$$\Rightarrow\ a=\frac{-m_2g}{2(m_1+m_2)}$$

So, the acceleration is opposite direction to that of assumed positive. Therefore, its right wards.

439. The tension of a stretched string is increased by 69%. In order to keep its frequency of vibration constant, its length must be increased by :

(a) 30% (b) 20%

(c) 69% (d) $\sqrt{69}$%

Karnataka CET-2002

Ans. (a) : Let the initial tension in the string be 'T'

When it increase by 69%, it becomes–

$$\frac{169}{100}T \text{ which is also equal to } 1.69T$$

If the initial frequency is:

$$f_1=\frac{1}{2L}\sqrt{\frac{100T}{\mu}}$$

Then, the new frequency,

$$f_2=\frac{1}{2L}\sqrt{\frac{169T}{\mu}}$$

by taking the ratios we have:

$$\frac{f_1}{f_2}=\frac{\sqrt{100T}}{\sqrt{169T}}$$

$$\frac{f_1}{f_2}=\frac{10}{13}$$

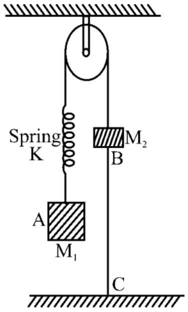
$$\because\quad f\propto\frac{1}{L}$$

Then, $\frac{f_1}{f_2}=\frac{L_2}{L_1}$

$$\frac{L_1}{L_2}=\frac{13}{10}$$

So, L_2 is 30% less than L_1 or L_1 is 30% increase than L_2.

440. In the system shown in figure $M_1 > M_2$ and pulley and threads are ideal. System is held at rest by thread BC. Just after thread BC is burnt.



(a) Acceleration M_1 and M_2 will be upward

(b) Magnitude of acceleration of both masses will be $\frac{M_1-M_2}{M_1+M_2}g$

(c) Acceleration of M_1 and M_2 will be equal to zero

(d) Acceleration of M_1 will be equal to zero, which that of m_2 will be $\frac{M_1-M_2}{M_2}g$ upward

Manipal UGET-2016

Ans. (d) : It is given that $M_1>M_2$. So, tension in string connecting the block and surface,

$T_{BC}=(M_1-M_2)g$

It is given in the question that the string BC is burnt then this tension disappear and the tension in spring becomes,

$T_{AB}=M_1g$

Net force exerted on the block B which is upward in direction,

$F_B=(M_1-M_2)g$

So, initial acceleration of block B,

$$a_i=\frac{\left(M_1-M_2\right)g}{M_2}$$

Thus, initial acceleration of mass M_1 is zero and the initial acceleration of mass M_2 is

$$\frac{\left(M_1-M_2\right)g}{M_2}\text{ upward .}$$

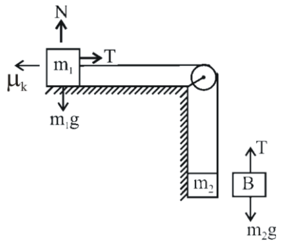
441. A block A of mass m1 rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of table and from its other end another block B of mass m2 is suspended. The coefficient of kinetic friction between the block and the table is □k. When the block A is sliding on the table, the tension in the string is

(a) $\frac{\left(m_2+\mu_km_1\right)g}{\left(m_1+m_2\right)}$ (b) $\frac{\left(m_2-\mu_km_1\right)g}{\left(m_1+m_2\right)}$

(c) $\frac{m_1m_2\left(1+\mu_k\right)g}{\left(m_1+m_2\right)}$ (d) $\frac{m_1m_2\left(1-\mu_k\right)g}{\left(m_1+m_2\right)}$

AIPMT- 2015

Ans. (c) :



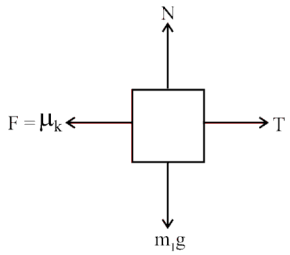
The blocks m_1 and m_2 are moving with combine acceleration a.

$F=\mu_kN$

$F=\mu_km_1g$

@apna_pdf

For block A :



$T - F = m_1a$

Since block m_1 is sliding kinetic energy will be acting

$\therefore \quad T - \mu_k m_1 g = m_1 a$ ....(i)

For block B :

$m_2g - T = m_2a$ ....(ii)

Adding equation (i) and (ii),

$$a = \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2} \quad \text{....(iii)}$$

From equation (ii),

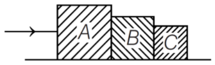
$$T = m_2g - m_2a$$

$$T = m_2\left(g - \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}\right)$$

$$T = m_2\left(\frac{m_1 g + \mu_k m_1 g}{m_1 + m_2}\right)$$

$$T = m_1 m_2\left(\frac{1 + \mu_k}{m_1 + m_2}\right)g$$

442. Three blocks A, B and C of masses 4 kg, 2 kg and 1 kg respectively, are in contact on a frictionless surface, as shown. If a force of 14 N is applied on the 4 kg block, then the contact force between A and B is



(a) 2 N (b) 6 N
(c) 8 N (d) 18 N

AIPMT- 2015

Ans. (b) : Given that,

Mass of block A = 4 kg

Mass of block B = 2 kg

Mass of block C = 1 kg

Force, F = 14 N

We know that ,

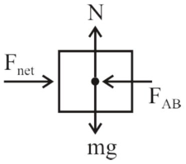
$$F = ma$$

$$F_{net} = m_{total} \times a$$

$$a = \frac{F_{net}}{m_{total}}$$

$$a = \frac{14N}{(4+2+1)} = 2\,m/s^2$$

For block A



$F_{net} - F_{AB} = m_Aa$

$14 - F_{AB} = 4 \times 2$

$F_{AB} = 14 - 8$

$F_{AB} = 6$ N

Hence, the contact force between A and B is 6 N.

443. A bullet of mass 20 gm is fired in horizontal direction with a velocity 150 m/s from a pistol of mass 1 kg. Recoil velocity of the pistol is

(a) 3 m/s (b) 3 km/s
(c) 300 m/s (d) 1/3 m/s

NDA (II) 2013

Ans. (a) : Given data,

$m_1 = 20$ gm, $v_1 = 150$ m/s

$u_1 = 0$ m/s, $m_2 = 1$ kg $= 1000$ gm

$u_2 = 0$ m/s

$v_2 = ?$

According to the law of conservation of momentum,

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$20 \times 0 + 1000 \times 0 = 20 \times 150 + 1000 \times v_2$

$1000v_2 = -3000$

$$v_2 = -\frac{3000}{1000}$$

$v_2 = -3$ m/s

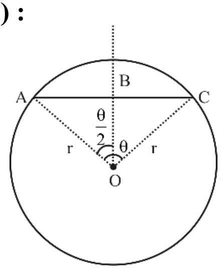
Negative sign shows that it is recoil velocity. The direction of recoil velocity is apposite to the direction of motion.

444. A particle is moving uniformly in a circular path of radius r. When it moves through an angular displacement θ, then the magnitude of the corresponding linear displacement will be

(a) $2r\cos\left(\frac{\theta}{2}\right)$ (b) $2r\cot\left(\frac{\theta}{2}\right)$
(c) $2r\tan\left(\frac{\theta}{2}\right)$ (d) $2r\sin\left(\frac{\theta}{2}\right)$

WB JEE-2014

Ans. (d) :



Linear displacement AC = AB + BC

In Δ ABO,

$$\sin\left(\frac{\theta}{2}\right) = \frac{AB}{r}$$

$$AB = r\sin\left(\frac{\theta}{2}\right)$$

In Δ BCO ,

$$\sin\left(\frac{\theta}{2}\right) = \frac{BC}{r}$$

$$BC = r\sin\left(\frac{\theta}{2}\right)$$

@apna_pdf

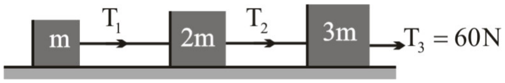
So, linear displacement (AC) = AB + BC

$$AC = r\sin\left(\frac{\theta}{2}\right) + r\sin\left(\frac{\theta}{2}\right)$$

$$AC = 2\,r\,\sin\left(\frac{\theta}{2}\right)$$

Hence, magnitude of the corresponding linear displacement will be $2r\sin\left(\frac{\theta}{2}\right)$.

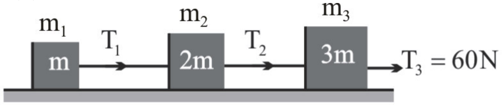
445. Three blocks of masses m, 2m and 3m are connected by massless strings as shown on a frictionless table. They are pulled with a force $T_3 = 60N$, the tension T_1 will be



(a) 10 N (b) 20 N
(c) 32 N (d) 40 N

UP CPMT-2010

Ans. (a) : Given, $m_1 = m$, $m_2 = 2m$, $m_3 = 3m$



$$F = ma$$

$$\text{Acceleration of system } (a) = \frac{T_3}{\text{total mass}}$$

$$a = \frac{T_3}{m_1 + m_2 + m_3}$$

$$a = \frac{60}{m + 2m + 3m}$$

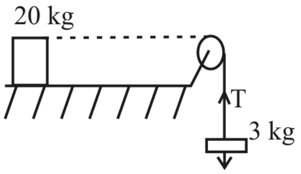
$$a = \frac{60}{6m} = \frac{10}{m}\ m/s^2$$

String T_1 pulls m mass

Therefore,

$$T_1 = ma = m \times \frac{10}{m} = 10\ N$$

446. A body of mass 20 kg is moving on a rough horizontal plane. A block of mass 3 kg is connected to the 20 kg mass by a string of negligible mass through a smooth pulley as shown in the figure. The tension in the string is 27 N. The coefficient of kinetic friction between the heavier mass and the surface is (g = 10 m/s^2)

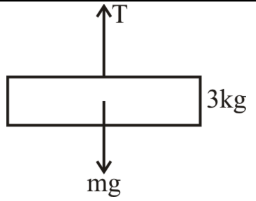


(a) 0.025 (b) 0.035
(c) 0.35 (d) 0.25

TS EAMCET (Engg.)-2016

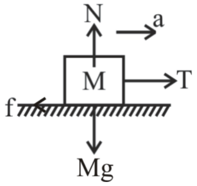
Ans. (b) : Given, T = 27 N μ = ?

For 3kg block,



$$mg - T = ma$$
$$3 \times 10 - 27 = 3a$$
$$3a = 3$$
$$a = 1\ ms^{-2} \qquad \ldots\ldots(i)$$

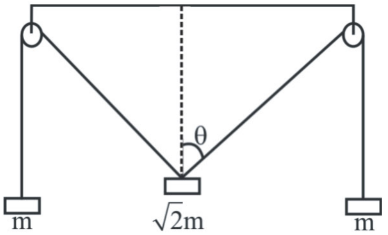
For 20 kg block,



Equation of motion,

$$T - f = Ma$$
$$T - \mu.N = Ma$$
$$T - \mu Mg = Ma$$
$$27 - \mu \times 20 \times 10 = 20 \times 1$$
$$27 - 200\,\mu = 20$$
$$\mu = \frac{7}{200} = 0.035$$

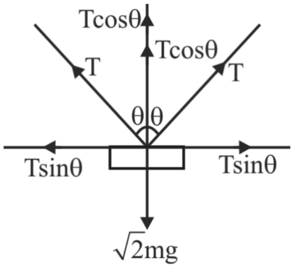
447. The pulleys and strings shown in figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be



(a) 45° (b) 60°
(c) 75° (d) 90°

SRM JEE - 2014

Ans. (a) : The free body diagram of the mass $\sqrt{2}m$ is shown in the figure



Balancing the force, we get

$$2T\cos\theta = \sqrt{2}mg \quad (\because T = mg \text{ at equilibrium})$$

$$2\cos\theta = \sqrt{2}$$

$$\cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45^\circ$$

@apna_pdf

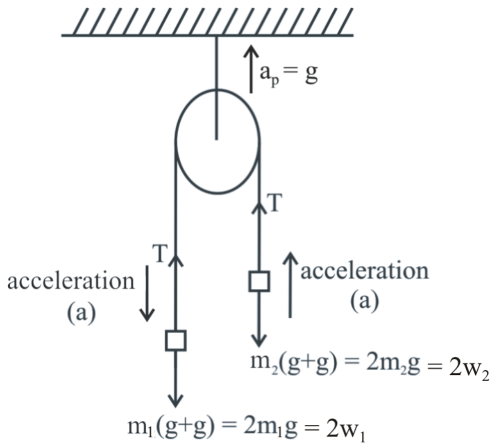
448. Two weights w_1 and w_2 are suspended to the two strings on a frictionless pulley. When the pulley is pulled up with an acceleration g, then the tension in the string is:

(a) $\frac{4w_1w_2}{w_1+w_2}$ (b) $\frac{w_1w_2}{w_1+w_2}$

(c) $\frac{2w_1w_2}{w_1+w_2}$ (d) $\frac{w_1+w_2}{2}$

JIPMER-2005

Ans. (a) :



According to above figure,

$2w_1 - T = m_1a$ ….. (i)

$T - 2w_2 = m_2a$ …..(ii)

Putting the value of a from equation (ii) to (i), we get–

$m_2(2w_1 - T) = m_1(T - 2w_2)$

$2m_2w_1 - m_2T = m_1T - 2m_1w_2$

$$T = \frac{2m_2w_1 + 2m_1w_2}{m_1 + m_2}$$

$$T = \frac{2\times\frac{w_2}{g}\times w_1 + 2\times\frac{w_1}{g}\times w_2}{\frac{w_1}{g}+\frac{w_2}{g}} \quad \left\{m_1 = \frac{w_1}{g} \text{ and } m_2 = \frac{w_2}{g}\right\}$$

$$T = \frac{4w_1w_2}{w_1+w_2}$$

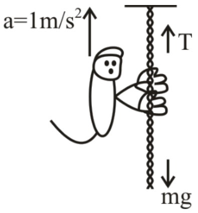
449. A monkey of mass 15 kg is climbing on a rope with one end fixed to the ceiling. If it wishes to go up with an acceleration 1 m/s^2, how much force should it apply to the rope if rope is 5 m long and the monkey starts from rest ?

(a) 150 N (b) >160 N

(c) 165 N (d) $150 < T \le 160$ N

JIPMEER-2015

Ans. (c) : Given that, mass of monkey = 15 kg, a = 1m/sec^2



From the figure, $T - mg = ma$

$T = m(g + a)$

$= 15(10 + 1) = 165$ N

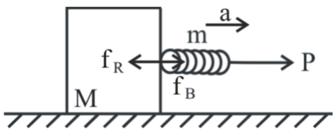
450. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is

(a) $\frac{PM}{(M+m)}$ (b) $\frac{PM}{(M-m)}$

(c) P (d) $\frac{PM}{(M-m)}$

AMU-2015

Ans. (a) :



Let, acceleration of system (rope + block) be 'a' along the direction of applied force.

$$\text{Acceleration of the system} = \frac{\text{Total external force}}{\text{Total mass}}$$

$$a = \frac{P}{m+M}$$

The force exerted by the rope on the block,

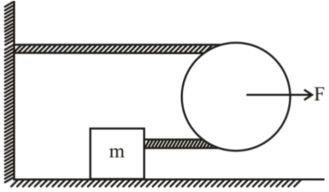
$P - f_R = ma$

$$f_R = P - ma = P - m\left(\frac{P}{m+M}\right)$$

$$= \frac{MP}{m+M}$$

$$f_R = f_B = \frac{MP}{m+M}$$

451. In the given figure the pulley is assumed mass less and frictionless. If the friction on the object of mass m is f, then its acceleration in terms of the force F will be equal to

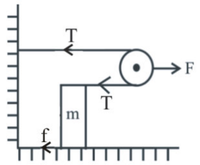


(a) (F – f)/m (b) $\left(\frac{F}{2} - f\right)/m$

(c) F/m (d) None of these

AMU-2005

Ans. (b) :

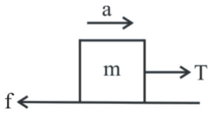


$2T = F$

or $T = F/2$

@apna_pdf

As the pulley is massless and frictionless net force on pulley will be zero.

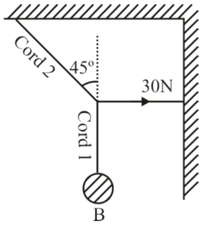


$$T - f = ma$$

$$a = \frac{T - f}{m}$$

$$a = \frac{\frac{F}{2} - f}{m} \qquad [\because F = 2T]$$

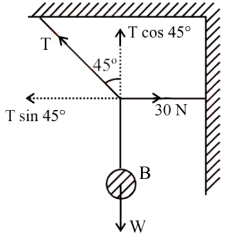
452. In the figure shown, the tension in the horizontal cord is 30 N. Find the weight of the body B.



(a) 40 N (b) 30 N
(c) 20 N (d) 10 N

AMU-2011

Ans. (b) : Free body diagram, for equilibrium



In the horizontal component,

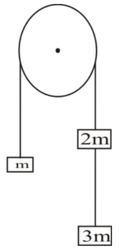
$$T \sin 45° = 30 \Rightarrow T = 30\sqrt{2}$$

In vertical component,

$$T \cos 45° = W$$

$$W = 30\sqrt{2} \times \frac{1}{\sqrt{2}} = 30 \text{ N}$$

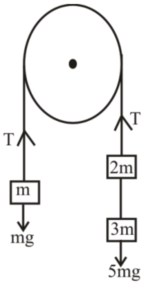
453. Three masses m, 2m and 3m are attached with light strings passing over a fixed frictionless pulley as shown in the figure. The tension in the string between 2m and 3m is (g is acceleration due to gravity)



(a) 6 mg (b) 3 mg
(c) 2 mg (d) 1 mg

AP EAMCET(Medical)-2016
JCECE-2016
UP CPMT-2011

Ans. (d) : Given figure-



Masses are m, 2m and 3m and T is the tension in the string

For block m,

$$T - mg = ma \qquad \text{.... (i)}$$

For block (2m + 3m),

$$5mg - T = 5ma \qquad \text{....(ii)}$$

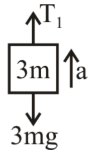
On adding equation (i) and (ii), we get –

$$4\ mg = 6\ ma$$

$$2g = 3a$$

$$a = \frac{2}{3}g$$

Let tension is T_1 between 2m & 3m, we get–



$$3mg - T_1 = 3ma$$

$$3mg - T_1 = 3m \times \frac{2}{3}g$$

$$3mg - T_1 = 2mg$$

$$T_1 = mg$$

454. A stone tied to a rope is rotated in a vertical circle with uniform speed. If the difference between the maximum and minimum tensions in the rope is 20 N, mass of the stone in kg is ($g = 10 ms^{-2}$)

(a) 0.75 (b) 1.0
(c) 1.5 (d) 0.5

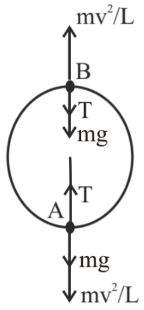
AP EAMCET(Medical)-2013

Ans. (b) : Given that,

Difference between maximum and minimum tension (ΔT) = 20 N

Acceleration due to gravity = 10 m/s^2

Assume the mass of the stone is 'm'



$$T_{max} = mg + \frac{mv^2}{L} \qquad \text{.....(i)}$$

@apna_pdf

$$T_{min} = \frac{mv^2}{L} - mg \qquad \ldots(ii)$$

$\Delta T = T_{max} - T_{min}$

$\Delta T = 2mg$ [From equ. (i) and (ii)]

$2mg = 20$

$mg = 10$

$$m = \frac{10}{g}$$

$$m = \frac{10}{10} \qquad [\because g = 10]$$

$m = 1kg$

455. A balloon starting from rest ascends vertically with uniform acceleration to a height of 100 m in 10 s. The force on the bottom of the balloon by a mass of 50 kg is ($g=10ms^{-2}$)

(a) 100 N (b) 300 N

(c) 600 N (d) 400 N

AP EAMCET(Medical)-2013

Ans. (c) : Given that,

Mass = 50 kg

Distance (s) = 100 m

Time = 10 sec

By using 2nd equation of motion-

$$s = ut + \frac{1}{2}at^2$$

$$s = 0 \times t + \frac{1}{2}at^2$$

$$a = \frac{2s}{t^2}$$

$$a = \frac{2\times 100}{(10)^2}$$

$$a = \frac{2\times 100}{100}$$

$a = 2m/s^2$

Considering the force acting on the balloon.

$ma = F_B - mg$

$F_B = m(g + a)$

$F_B = 50(10+2)$

$F_B = 50 \times 12$

$F_B = 600$ N

Thus is also the same force exerted by 50 kg on bottom of balloon.

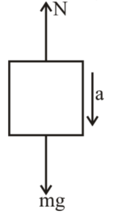
456. A lift is moving with a retardation of $5m/s^2$. The percentage change in the weight of person in the lift is ($g = 10ms^{-2}$) :

(a) 100 (b) 25

(c) 50 (d) 75

AP EAMCET(Medical)-1998

Ans. (c) : Given, $a = -5\ m/s^2$, $g = 10\ m/s^2$



Form figure, in vertical component,

$N - mg = -ma$

$N = -ma + mg$

$= -5m + 10\ m = 5\ m$

$$\%\text{ change in weight} = \frac{\Delta W}{W}\times 100 = \frac{mg - N}{mg}\times 100$$

$$= \frac{10m - 5m}{10m}\times 100 = 50\%$$

457. A lift is moving upward with increasing speed with acceleration a. The apparent weight will be

(a) less than the actual weight

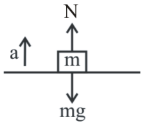
(b) more than the actual weight and have a fixed value

(c) more than the actual weight which increases as long as velocity increases

(d) zero

DCE-2009

Ans. (b) : Lift accelerating upward with acceleration a,



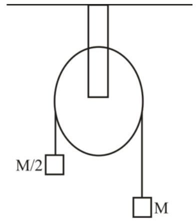
$N - mg = ma$

$N = ma + mg$

$N = m(a + g)$

Thus, apparent weight will be more than the actual weight and have a fixed value.

458. Two masses M and M/2 are joined together by means of light inextensible string passed over a frictionless pulley as shown in the figure. When the bigger mass is released, the small one will ascend with an acceleration of:



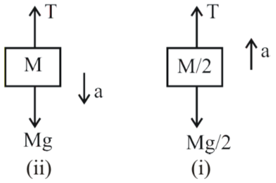
(a) $\frac{g}{3}$ (b) $\frac{3g}{2}$

(c) $\frac{g}{2}$ (d) g

(e) $\frac{g}{4}$

UP CPMT-2013
UPSEE - 2010
Kerala CEE 2005
AIPMT- 2000

Ans. (a) : From free body diagram,



@apna_pdf

From F.B.D (i),

$$T-\frac{Mg}{2}=\frac{Ma}{2} \qquad .....(i)$$

From F.B.D (ii),

$$Mg-T=Ma \qquad .....(ii)$$

On adding equation (i) and (ii), we get-

$$Mg-\frac{Mg}{2}=\frac{Ma}{2}+Ma$$

$$\frac{Mg}{2}=\frac{3Ma}{2}$$

$$a=\frac{g}{3}$$

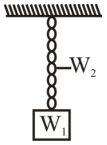
459. A body of weight W_1 is suspended from the ceiling of a room through a chain of weight W_2. The ceiling pulls the chain by a force

(a) W_1 (b) W_2

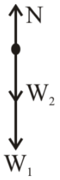
(c) W_1+W_2 (d) $\frac{W_1+W_2}{2}$

SRMJEE - 2015

Ans. (c) : A body of weight (W_1) is suspended from a ceiling though a chain we weight (W_2) as shown in the figure –



The free body diagram of the chain will be –



The ceiling pulls the chain by a force (W_1+W_2).

For free body diagram

$$(W_1+W_2)-N=0$$

$$N=W_1+W_2$$

460. A monkey climbs up and another monkey climbs down a rope hanging from a tree with same uniform acceleration separately. If the respective masses of monkeys are in the ratio 2:3, the common acceleration must be :

(a) g/5 (b) 6g

(c) g/2 (d) g

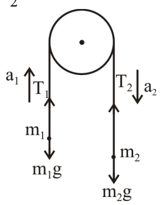
(e) g/3

Kerala CEE 2006

Ans. (a) : Given that, if the respective masses of monkeys are in the ratio 2 : 3,

Then,

$$\frac{m_1}{m_2}=\frac{2}{3}$$



A monkey climbs up and other monkey climbs down a rope hanging a tree with same uniform acceleration separately.

Let, T be the tension in rope.

Acceleration (a) and Tension (T) are same.

$$\therefore\ T_1=T_2=T$$

And $a_1=a_2=a$

Now, $T_1-m_1g=m_1a_1$ ....(i)

And, $m_2g-T_2=m_2a_2$ ....(ii)

Adding the equation (i) and equation (ii)

$$(T_1-m_1g)+(m_2g-T_2)=m_1a_1+m_2a_2$$

$$T_1=T_2=T$$

$$T-m_1g+m_2g-T=m_1a_1+m_2a_2$$

$$a_1=a_2=a$$

$$m_2g-m_1g=m_1a+m_2a$$

$$g(m_2-m_1)=a(m_1+m_2)$$

$$gm_2\left(1-\frac{m_1}{m_2}\right)=a\ m_2\left(\frac{m_1}{m_2}+1\right)$$

$$g\left(1-\frac{m_1}{m_2}\right)=a\left(\frac{m_1}{m_2}+1\right)$$

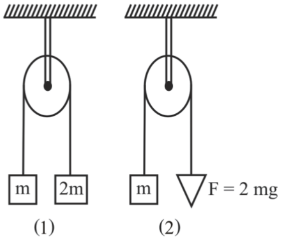
$$g\left(1-\frac{2}{3}\right)=a\left(\frac{2}{3}+1\right)$$

$$g\left(\frac{3-2}{3}\right)=a\left(\frac{2+3}{3}\right)$$

$$g=5a$$

$$\boxed{a=\frac{g}{5}}$$

461. Two pulley arrangements of figure given are identical. The mass of the rope is negligible. In figure (1), the mass m is lifted by attaching a mass 2m to the other end of rope. In figure (2), m is lifted up by pulling the other end of the rope with a constant downward force F = 2 mg. The acceleration of m in the two cases are respectively



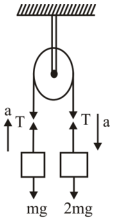
(a) 3g, g (b) g/3, g

(c) g/3, 2g (d) g, g/3

AIIMS-2013

Ans. (b) : Let a and a' be the accelerations in both cases respectively.

From figure (1),



(a)

@apna_pdf

T–mg = ma ....(i)

And

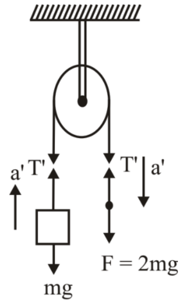
2mg – T = 2ma .....(ii)

Adding equation (i) and (ii), we get

mg = 3ma

$\therefore a = \frac{g}{3}$

From figure (2),


a'
T'
T'
a'
mg
F = 2mg

(b)

T – mg = ma' ....(iii)

and 2mg – T = 0

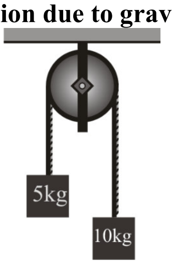
Solving equation (iii) and (iv) we get,

mg = ma'

a' = g

$\therefore a = \frac{g}{3}$ and a' = g

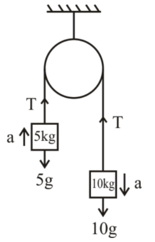
462. Two masses of 5 kg and 10 kg are connected to a pulley as shown. What will be the acceleration of the system?
(g = acceleration due to gravity)



(a) g (b) g/2
(c) g/3 (d) g/4

UP CPMT-2010

Ans. (c) :


T
a
5kg
5g
T
10kg
a
10g

For 5 kg mass–

$T - 5g = 5a$ .....(i)

For 10kg mass–

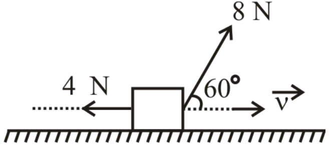
$10g - T = 10a$ .....(ii)

From equation (i) and (ii)

$5g = 15a$

$a = \frac{g}{3}$

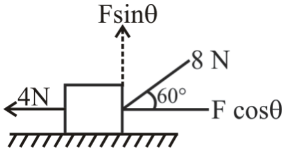
463. Two forces of magnitudes 4 N and 8 N are acting on a box, when the box moves rightward across a frictionless horizontal support. The speed of the box at time t is $1\,m\,s^{-1}$. the change in kinetic energy of the box is


8 N
4 N
60°
$\vec{v}$

(a) Zero (b) 80 J
(c) 8 J (d) 4 J

Assam CEE-2016

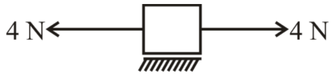
Ans. (a) :


Fsinθ
8 N
4N
60°
F cosθ

From above figure-

$F\cos60° = 8 \times \frac{1}{2} = 4\text{ N}$

Now,

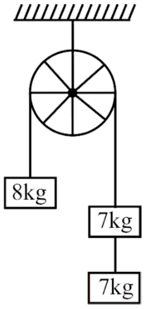


$F_{net} = 0$

Block is rest.

Hence, ΔK.E. = 0

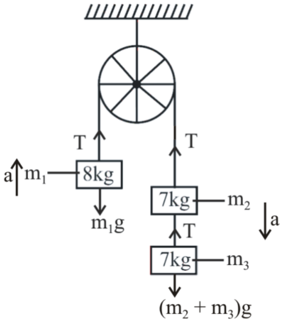
464. A light string passes over a frictionless pulley. To one of its ends a mass of 8 kg is attached. To its other end two masses of 7 kg each are attached. The acceleration of the system will be



(a) 10.2 g (b) 5.10 g
(c) 20.36 g (d) 0.27 g

JIPMER-2016

Ans. (d) :


T
T
a
m_1
8kg
m_1g
7kg
m_2
a
T
7kg
m_3
$(m_2 + m_3)g$

@apna_pdf

From the free body diagram,

$$m_1a = T - m_1g$$

$$8a = T - 8g$$

$$T = 8a + 8g \quad \text{...(i)}$$

After combining the mass of m_2 and m_3,

$$m_2 + m_3 = 7 + 7 = 14 \text{ kg}$$

Now, from the free body diagram,

$$(m_2 + m_3)a = (m_2 + m_3)g - T$$

$$14a = 14\,g - T \quad \text{...(ii)}$$

From the equation (i) putting the value of T in equation (ii)

Now, $$14a = 14g - (8a + 8g)$$

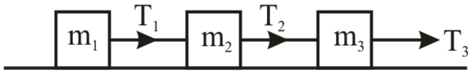
$$14a + 8a = 14g - 8g$$

$$22a = 6g$$

$$a = \frac{6}{22}g$$

$$a = 0.27g$$

465. Three blocks of masses m_1, m_2 and m_3 are connected by massless string as shown kept on a frictionless table.



They are pulled with a force T_3 = 40 N. If m_1 = 10 kg, m_2 = 6 kg and m_3 = 4kg, the tension T_2 will be:

(a) 20 N (b) 40 N
(c) 10 N (d) 32 N
(e) 16 N

Kerala CEE 2006

Ans. (d) : Given,

Total mass of system $(m_1 + m_2 + m_3)$ = 20 kg

We know that, force on the block

$$F = (m_1 + m_2 + m_3) \times a$$

$$a = \frac{F}{m_1 + m_2 + m_3}$$

$$a = \frac{40}{10+6+4} = 2\text{m/s}^2$$

Tension of T_2 will be –

$$T_3 - T_2 = m_3a$$

$$40 - T_2 = 4 \times 2$$

$$T_2 = 32 \text{ N}$$

466. A mass of 1 kg is suspended by a thread. It is 1. lifted up with an acceleration 4.9 m/s^2, 2. lowered with an acceleration 4.9 m/s^2. The ratio of the tensions is

(a) 3:1 (b) 1:3
(c) 1:2 (d) 2:1

AIPMT- 1998

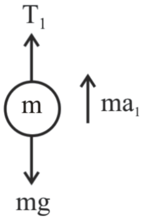
Ans. (a) : Given

$a = 4.9 \text{ m/s}^2$

$m = 1$ kg

$g = 9.8 \text{ m/s}^2$

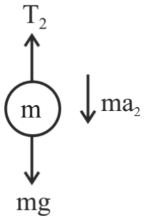
Magnitude of tension = T



Case I: A mass is lifted with an acceleration 4.9 m/s^2.

Thus, tension developed in the string,

$$T_1 = mg + ma_1 \quad \text{....(i)}$$



Case II: A mass is lowered with an acceleration 4.9 m/s^2

Tension developed in the string

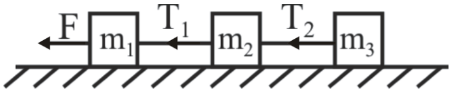
$$T_2 = mg - ma_2 \quad \text{....(ii)}$$

From eqn (i) and (ii), we get

$$\frac{T_1}{T_2} = \frac{g+a_1}{g-a_2} = \frac{9.8+4.9}{9.8-4.9}$$

$$\frac{T_1}{T_2} = \frac{14.7}{4.9} = \frac{3}{1} = 3:1$$

467. Three blocks of masses 2 kg, 3 kg and 5 kg are connected to each other with light string and then place on a frictionless surface. The system is pulled by a force F = 10 N, then tension T_1 is.



(a) 1N (b) 5 N
(c) 8N (d) 10N

UP CPMT-2014

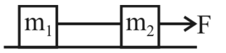
Ans. (c) : Total mass of the system (M) = $(m_1 + m_2 + m_3) = (2+3+5) = 10$ kg

Hence, tension in T_1-

$$T_1 = \left(\frac{m_2 + m_3}{m_1 + m_2 + m_3}\right)g = \left(\frac{3+5}{2+3+5}\right) \times 10$$

$$T_1 = 8\text{N}$$

468. Two masses m_1 and m_2 are placed on a smooth horizontal surface and are connected by a string of negligible mass. A horizontal force F is applied on the mass m_2 as shown in the figure. The tension in the string is



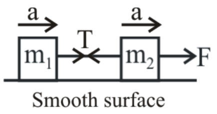
(a) $\left(\frac{m_1}{m_1 + m_2}\right)F$ (b) $\frac{m_2F}{m_1 + m_2}$

@apna_pdf

(c) $\left(\frac{m_1}{m_2}\right)F$ (d) $\frac{m_2F}{m_1}$

TS EAMCET (Engg.)-2016

Ans. (a) :



$$F = ma$$

$$a = \frac{F}{m_1 + m_2} \quad .....(i)$$

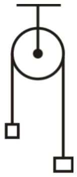
Force on m_1 = Tension in string (T)

$$T = m_1a \quad .....(ii)$$

On solving equation (i) and (ii), we get–

$$T = m_1\left(\frac{F}{m_1 + m_2}\right)$$

469. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking g = 10 m/s^2, find the work done (in joules) by the string on the block of mass 0.36 kg during the first second after the system is released from rest.



(a) 4 J (b) 2 J

(c) 8 J (d) 10 J

BITSAT-2013

Ans. (c): Given,

Masses of two blocks

$m_1 = 0.36$ kg, $m_2 = 0.72$ kg

From free body diagram–

Both block start to move with acceleration 'a' after the rest.

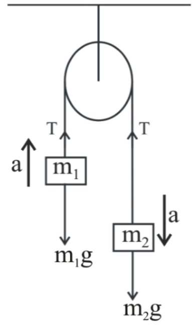
So,

Blocks with mass m_1, will be-

$$T - m_1g = m_1a \quad ....(i)$$

Block with mass m_2, will be-

$$m_2g - T = m_2a \quad ....(ii)$$



Adding both equation (i) and (ii), we get-

$$m_2g - m_1g = m_1a + m_2a$$

$$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)g$$

$$a = \left(\frac{0.72 - 0.36}{0.36 + 0.72}\right)g = \frac{g}{3}$$

Now, substituting the value of 'a' in equation (i) for getting the value of tension,

$$T - m_1g = m_1\frac{g}{3}$$

$$T = m_1\left(1 + \frac{1}{3}\right)g$$

$$T = \frac{4}{3}m_1g = \frac{4}{3} \times 0.36 \times 10$$

$$T = 4.8 \text{ N}$$

Height ascended by the block of mass in one second

$$s = ut + \frac{1}{2}at^2$$

$$s = \frac{at^2}{2} = \frac{g}{6} \qquad \left(\because u = 0, a = \frac{g}{3}, t = 1\text{sec}\right)$$

So, work done by block (W) = T × s

$$W = 4.8 \times \frac{g}{6} = \frac{4.8 \times 10}{6}$$

$$W = 8 \text{ J}$$

470. The displacement x of a particle at time t moving under a constant force is t = $\sqrt{x} + 3$, x in meters, t in seconds. Find the work done by the force in the interval from t = 0 to t = 6 second.

(a) 10 (b) 0

(c) 5 (d) 2

WB JEE 2009

Ans. (b) : Given equation can be written as,

$$x = (t - 3)^2$$

$$v = \frac{dx}{dt} = 2(t - 3)$$

In the interval t = 0 to t = 6

$$v_f = 2(6 - 3) = 6$$

$$v_i = 2(0 - 3) = -6$$

So, from work-energy theorem

$$W = \Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

$$= \frac{1}{2}m\left[6^2 - (-6)^2\right] = 0$$

Work done by the force in the first 6s is zero.

@apna_pdf

(f) Friction, and Inclined Plane Friction Motion

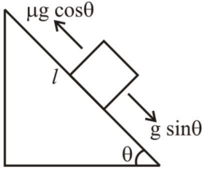
471. The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction

(a) $\sqrt{1-\frac{1}{n^2}}$ (b) $\sqrt{\frac{1}{1-n^2}}$

(c) $1+\frac{1}{n^2}$ (d) $1-\frac{1}{n^2}$

JEE Main-29.01.2023, Shift-II

Ans. (d) : According to the question,



Then, total acceleration in downward direction,

$a = g\sin\theta - \mu g\cos\theta$

By second equation of motion, $h = ut+\frac{1}{2}at^2$

$l = \frac{1}{2}g\sin\theta\ t_1^2 = \frac{1}{2}g(\sin\theta - \mu\cos\theta)t_1^2$

Given, $t_2 = n\,t_1$

$1 = (1-\mu)n^2$

$\mu = 1 - \frac{1}{n^2}$

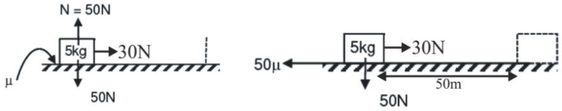
472. A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10 s. Coefficient of kinetic friction is (given g = 10 ms^{-2})

(a) 0.50 (b) 0.60

(c) 0.75 (d) 0.25

JEE Main-01.02.2023, Shift-I

Ans. (a) : Given, mass = 5kg and force = 30N



Resolving the forces along x axis –

$\sum F_x = 0$

N = 50N

Friction force, $F_s = \mu N$

$F_s = 50\mu$

Then,

$F_{net} = (30-50\mu)N$

$F = ma_{net}$

$a_{net} = \frac{30-50\mu}{5} = (6-10\mu)m/s^2$

From second equation of motion

$S = ut+\frac{1}{2}at^2$

$50 = 0(t)+\frac{1}{2}(6-10\mu)(10)^2$

$50 = 1/2(6-10\mu)100$

$\frac{50\times 2}{100} = (6-10\mu)$

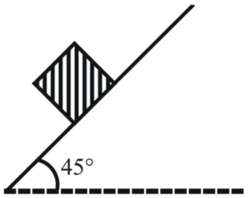
$6-10\mu = 1$

$10\mu = 6-1 = 5$

$\mu = 5/10 = 0.5$

$\mu = 0.5$

473. Consider a block kept on an inclined plane (inclined at 45°) as shown in the figure. If the force required to just push it up the incline is 2 times the force required to just prevent if from sliding down, the coefficient of friction between the block and inclined plane(μ) is equal to :



(a) 0.50 (b) 0.33

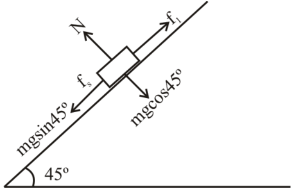
(c) 0.25 (d) 0.60

JEE Main-25.01.2023, Shift-II

Ans. (b) : Case I -

Upward force.

$f_1 = mg\sin 45° + f_s$

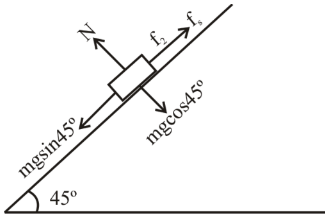


$f_1 = mg\sin 45° + \mu N$

$f_1 = \frac{mg}{\sqrt{2}} + \mu mg\cos 45°$

$f_1 = \frac{mg}{\sqrt{2}}(1+\mu)$ ......(i)

Case II -



$f_2 = mg\sin 45° - f_s$

$mg\sin 45° - \mu N$

$\frac{mg}{\sqrt{2}} - mg\cos 45°$

@apna_pdf

$$\frac{mg}{\sqrt{2}}(1-\mu) \qquad \text{......(ii)}$$

Then given condition $f_1 = 2f_2$

$$\frac{mg}{\sqrt{2}}(1+\mu) = 2 \times \frac{mg}{\sqrt{2}}(1-\mu)$$

$$1 + \mu = 2 - 2\mu$$

$$\mu = \frac{1}{3} = 0.33$$

474. A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient if friction is: (Take acceleration due to gravity gm = 10ms^{-2})

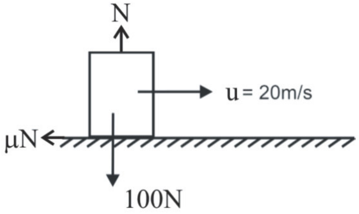
(a) 0.2 (b) 0.4

(c) 0.5 (d) 0.3

JEE Main-31.01.2023, Shift-II

Ans. (b) : Given, initial velocity (u) = 20m/s and time (t) = 5sec

Let, final velocity = v



Resolving the force along y-axis –

$$\sum F_y = 0,$$

$$N = 100N$$

Friction force = μN = μ(100)

$$\text{Retardation (a)} = -\frac{100\mu}{10}$$

$$a = -10\mu$$

From first equation of motion –

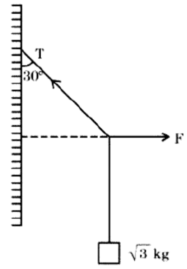
$$v = u + at$$

$$0 = 20 + (-10\mu)(5)$$

$$50\mu = 20$$

$$\mu = \frac{20}{50} = \frac{2}{5} = 0.4$$

475. A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that string makes an angle of 30º with the wall. The tension T is:

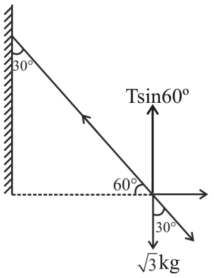


(a) 25 N (b) 15 N

(c) 10 N (d) 20 N

JEE Main-30.01.2023, Shift-II

Ans. (d) :



Resolving force along y-axis –

$$T \sin 60° = \sqrt{3}g$$

$$T \times \frac{\sqrt{3}}{2} = \sqrt{3} \times 10$$

$$T = 20N$$

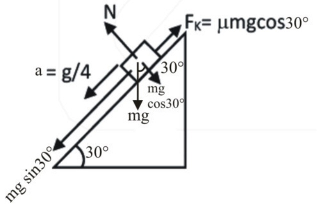
476. A block of mass m slides down the plane inclined at angle 30º with an acceleration g/4. The value of coefficient of kinetic friction will be :

(a) $\frac{2\sqrt{3}+1}{2}$ (b) $\frac{2\sqrt{3}-1}{2}$

(c) $\frac{\sqrt{3}}{2}$ (d) $\frac{1}{2\sqrt{3}}$

JEE Main-29.01.2023, Shift-I

Ans. (d) : According to the question,



Resolving the forces parallel to plane –

$$mg \sin 30° - \mu mg \cos 30° = ma$$

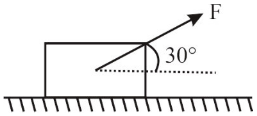
$$\frac{g}{2} - \frac{\mu g\sqrt{3}}{2} = \frac{g}{4}$$

$$\frac{1}{2} - \frac{\sqrt{3}\mu}{2} = \frac{1}{4}$$

$$\frac{1}{2} - \frac{1}{4} = \frac{\sqrt{3}}{2}\mu$$

$$\mu = \frac{1}{2\sqrt{3}}$$

477. As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30°, with horizontal. For μ_s = 0.25, the block will just start to move for the value of F : [Given g = 10 ms^{-2}]



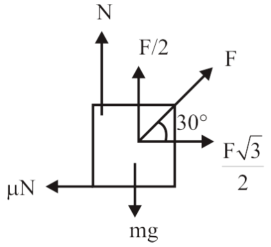
(a) 20 N (b) 35.7 N

(c) 33.3 N (d) 25.2 N

JEE Main-01.02.2023, Shift-II

@apna_pdf

Ans. (d) : FBD of the block



Resolving the forces along y-axis –

$$N = mg - \frac{F}{2}$$

$$F_s = \mu N = 0.25\left[100 - \frac{F}{2}\right]$$

Condition so that block can slide

$$F \cos 30° \geq f_s$$

$$\frac{\sqrt{3}F}{2} \geq 0.25\left[100 - \frac{F}{2}\right]$$

$$= \frac{200}{4\sqrt{3}+1}$$

$$F = 25.2N$$

478. An object takes n times as much time as to slide down a 45° rough inclined plane as it takes to slide down perfectly smooth inclined planned of the same inclination. The coefficient of kinetic friction between the object and the rough incline is given by

(a) $\left(1 - \frac{1}{n^2}\right)$ (b) $\left(\frac{1}{1-n^2}\right)$

(c) $\sqrt{1 - \frac{1}{n^2}}$ (d) $\sqrt{1 + \frac{1}{n^2}}$

AP EAMCET-24.04.2019, Shift-II
AMU-2018, 2014
SCRA-2014
AIIMS-2016
AP EAMCET -2010

Ans. (a): We know that,

Smooth plane of acceleration (a) = g sinθ

For rough plane of acceleration (a) = g (sinθ – μ cosθ)

From , Newton's Law of motion,

$$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2 \qquad (\because u = 0)$$

$$t = \sqrt{\frac{2s}{a}}$$

$$t_{rough} = nt_{smooth}$$

$$\sqrt{\frac{2s}{g(\sin\theta - \mu\cos\theta)}} = n \times \sqrt{\frac{2s}{g\sin\theta}}$$

Squaring both side, we get–

$$\frac{2s}{g(\sin\theta - \mu\cos\theta)} = n^2 \times \frac{2s}{g\sin\theta}$$

$$n^2 = \frac{g\sin\theta}{g(\sin\theta - \mu\cos\theta)}$$

$$n^2 = \frac{\sin 45°}{\sin 45° - \mu\cos 45°} \qquad (\because \theta = 45°)$$

$$n^2 = \frac{1/\sqrt{2}}{1/\sqrt{2} - \mu \times 1/\sqrt{2}}$$

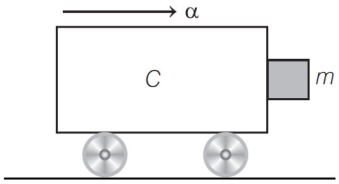
$$n^2 = \frac{1}{(1-\mu)}$$

$$n^2 - n^2\mu = 1$$

$$n^2\mu = n^2 - 1$$

$$\mu = \left(1 - \frac{1}{n^2}\right)$$

479. A block of mass m is in contact with the cart C as shown in the figure.



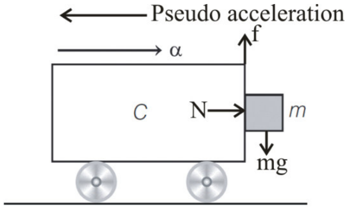
The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies

(a) $\alpha > \frac{mg}{\mu}$ (b) $\alpha > \frac{g}{\mu m}$

(c) $\alpha \geq \frac{g}{\mu}$ (d) $\alpha < \frac{g}{\mu}$

AIPMT- 2010
BCECE-2017

Ans. (c) :



The above diagram display as the forces working on a block of mass m.

Therefore,

$$m\alpha = \text{pseudo forces}$$

Frictional forces

$$F_s \geq mg$$

$$\mu N \geq mg \qquad (\therefore N = m\alpha)$$

$$\mu m\alpha \geq mg$$

$$\Rightarrow \qquad \alpha \geq \frac{g}{\mu}$$

480. If reaction is R and coefficient of friction is μ_r what is the work done against friction in moving a body by distance d?

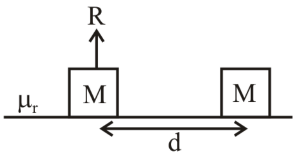
(a) $\frac{\mu_r Rd}{4}$ (b) $2\mu_r Rd$

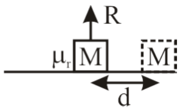
(c) $\mu_r Rd$ (d) $\frac{\mu_r Rd}{2}$

AMU-2017
DCE-2007

@apna_pdf

Ans. (c) :





Frictional force $F_r = \mu_r R$

Work done by frictional force $= F_r.d$

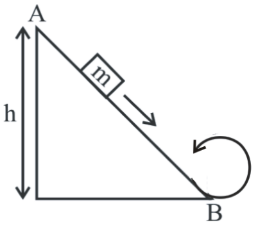
$= \mu_r Rd$

481. A body of mass m slides down along a frictionless inclined plane from height 'h' and just completes motion in a vertical circle of radius 2m after reaching the bottom. What is the value of h?
[Use $g = 10 m/s^2$]

(a) 2 m
(b) $\frac{5}{2}$m
(c) 5 m
(d) 10 m

TS EAMCET 19.07.2022, Shift-II

Ans. (c) :



The body can describe circular path if the velocity of the body at lowest point B of the circular path is-

$$v = \sqrt{5gr}$$
$$v = \sqrt{5 \times 10 \times 2}$$
$$v = \sqrt{100} = 10 \text{ m/s}$$

At point A there is only potential energy and at the point B energy is completely kinetic

∴ Kinetic energy of body at point B is -

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2} \times m \times (10)^2 = 50 \text{ m}$$

∴ Potential energy at point A is-

$= mgh$

From law of conservation of energy-

P.E. = K.E.

mgh = 50m

$$h = \frac{50}{g} = 5\text{m}$$

482. A cyclist is riding with a speed of 36km/h. As he approaches a circular turn on the road of radius 50, he applies brakes and reduces his speed at the constant rate of 0.5 m/s every second. The magnitude and direction of the net acceleration of the cyclist on the circular turn respectively are

(a) $\frac{\sqrt{3}}{2} m/s^2, \tan^{-1}(4)$

(b) $\frac{\sqrt{3}}{2} m/s^2, \tan^{-1}\left(\frac{1}{4}\right)$

(c) $\sqrt{17} m/s^2, \tan^{-1}\left(\frac{1}{4}\right)$

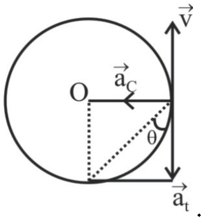
(d) $\frac{\sqrt{17}}{2} m/s^2, \tan^{-1}(4)$

TS EAMCET 20.07.2022, Shift-II

Ans. (d) : Radius of the circular turn (r) = 50 m

Tangential acceleration $(\vec{a}_t) = 0.5 \text{ m/s}^2$

Centripetal acceleration $(\vec{a}_c) = ?$



We know that,

$$\vec{a}_c = \frac{v^2}{r} = \frac{(10)^2}{50} = 2 \text{ m/s}^2$$

As shown in figure two accelerations are multually perpendicular directions.

So, the resultant acceleration is given by

$$\vec{a}_{net} = \sqrt{\vec{a}_t^2 + \vec{a}_c^2} = \sqrt{(0.5)^2 + (2)^2}$$

$$\vec{a}_{net} = \frac{\sqrt{17}}{2} \text{ m/s}^2$$

Hence, $\tan\theta = \frac{a_c}{a_t} = \frac{2}{0.5} = 4$

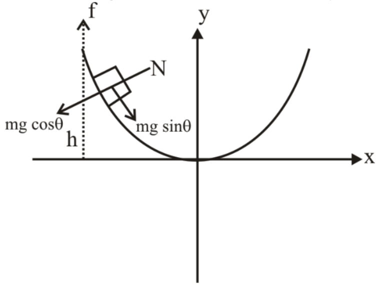
$\theta = \tan^{-1}(4)$

483. A block is placed on a parabolic shape ramp given by equation $y = \frac{x^2}{20}$. If the coefficient of static friction (μ_s) is 0.5. then what is the maximum height above the ground at which the block can be placed without slipping?

(a) 2.5 m
(b) 1.25 m
(c) 0.5 m
(d) 0.25 m

TS EAMCET 18.07.2022, Shift-II

Ans. (b) : Limiting friction force (f) = $\mu N = \mu_s mg\cos\theta$



In equilibrium, mg sinθ = $\mu_s mg\cos\theta$

$$\frac{\sin\theta}{\cos\theta} = \mu_s$$

$\tan\theta = \mu_s$

$\tan\theta = 0.5$

@apna_pdf

Given, $y = \frac{x^2}{20}$ ……. (i)

$$\frac{dy}{dx} = \frac{2x}{20} = \frac{x}{10}$$

$\tan\theta = \frac{x}{10}$ ……(ii)

Putting value of tan θ in equation (ii), we get

$$0.5 = \frac{x}{10}$$

$x = 5$

Putting value of x in equation (i), we get

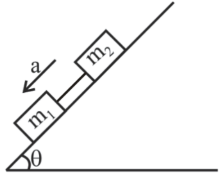
$$h = y_{max} = \frac{x^2}{20} = \frac{(5)^2}{20} = 1.25\text{m}$$

484. Two blocks of masses 1 kg and 2 kg connected by a light rod and the system is slipping down rough incline angle 45° with the horizontal. The frictional coefficient at both the contacts is 0.4. If the acceleration of the system is $\alpha\sqrt{2}$, the value of α is
(Use g = 10 m/s^2)

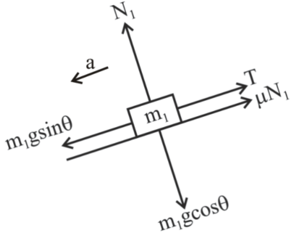
(a) 4 (b) 3
(c) 2 (d) 6

TS EAMCET 18.07.2022, Shift-I

Ans. (b) : Given, $m_1 = 1$ kg, $m_2 = 2$kg, $\theta = 45^o$, $\mu = 0.4$
According to question-



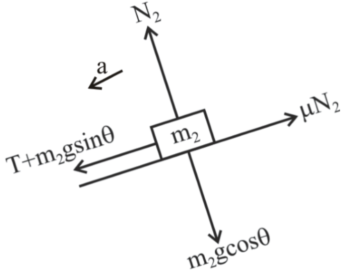
From free body diagram for m_1 block-



$N_1 = m_1 g\cos\theta$

$m_1 g\sin\theta - T - \mu N_1 = m_1 a$ …..(i)

From free body diagram for m_2 block-



$N_2 = m_2 g\cos\theta$

$T + m_2 g\sin\theta - \mu N_2 = m_2 a$ ….(ii)

On adding equation (i) and (ii), we get

$(m_1 + m_2)g\sin\theta - \mu(N_1 + N_2) = (m_1 + m_2)a$

$(m_1 + m_2)g\sin\theta - \mu(m_1 g\cos\theta + m_2 g\cos\theta) = (m_1 + m_2)a$

$(m_1 + m_2)g\sin\theta - \mu g\cos\theta(m_1 + m_2) = (m_1 + m_2)a$

$g\sin\theta - \mu g\cos\theta = a$

$10 \times \sin45° - 0.4 \times 10 \times \cos45° = a$

$$\frac{10}{\sqrt{2}} - \frac{4}{\sqrt{2}} = a$$

$$a = \frac{6}{\sqrt{2}}$$

$a = 3\sqrt{2}$

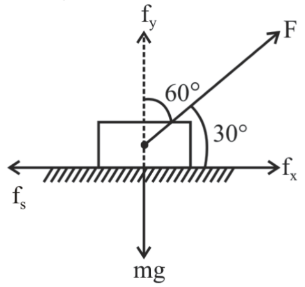
From question acceleration of system is $\alpha\sqrt{2}$. On comparing we get, α = 3

485. A 10 kg box is pulled on a rough horizontal surface. The force 40 N is applied at 60^o angle from vertical. If co-efficient of kinetic friction is 0.25, what will the acceleration of the moving box? (Consider g=10 m/s^2)

(a) 0.76m/s^2 (b) 1.52m/s^2
(c) 1.46m/s^2 (d) 0.68m/s^2

TS EAMCET 31.07.2022, Shift-II

Ans. (c) : Given,
Mass of box (m) = 10 kg
F = 40 N
Kinetic friction (μ) = 0.25
g = 10 m/s^2 and vertical angle = 60°
Then, horizontal angle is = 90° – 60° = 30°



Horizontal co-efficient of force, $F_x = F\cos30^o$

$F_x = 40\cos30^o$

$$F_x = 40 \times \frac{\sqrt{3}}{2}$$

$F_x = 20\sqrt{3}$

$F_x = 34.64$ N

Vertical co-efficient of force, $F_y = F\sin30^o$

$= 40 \times ½$

$= 20$ N

Normal = mg = 10 × 10 = 100 N

$F_{Normal} = 100 - 20 = 80$N

Friction force = μN

$f = 0.25 \times 80 = 20$ N

Net force to move the object $(F_{net}) = F_x - f$

$F_{net} = 34.64 - 20$

$F_{net} = 14.64$

$F_{net} = 14.64$

∴ m × a = 14.64 (∵ F = ma)

$$a = \frac{14.64}{10}$$

$a = 1.46$ m/s^2

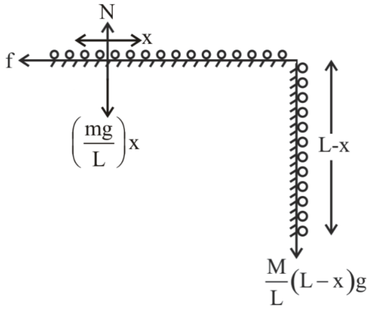
@apna_pdf

486. A heavy uniform chain lies on a horizontal table-top. If the coefficient of friction between the chain and table surface is 0.25, then the maximum fraction of length of the chain, that can hang over one edge of the table is-

(a) 20% (b) 25%
(c) 35% (d) 15%

CG PET-22.05.2022

Ans. (a) :



Given, friction (μ) = 0.25
From fig.

$$\therefore\ f_{max} = \mu\frac{M}{L}xg \quad \text{\_\_\_(i)}$$

Weight of hanging chain

$$W = \frac{M}{L}(L-x)g \quad \text{\_\_\_(ii)}$$

Equating eq^n (i) & (ii)

$$\mu\frac{M}{L}xg = \frac{M}{L}(L-x)g$$

$$\mu x = (L-x)$$

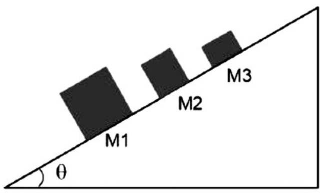
$$0.25\,x = L-x$$

$$1.25x = L$$

$$x = \frac{1}{1.25}L = \frac{4}{5}L$$

Hanging Part is L/5 which is 20% of the total L
So, A is correct option.

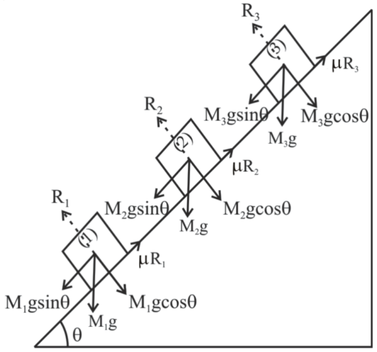
487. Consider three masses M_1, M_2 and M_3 ($M_1 > M_2 > M_3$) are at rest on a horizontal plane as shown in the figure. Now the angle of inclination (θ) of the plane is gradually increased until the masses just begin to slide. (Assume the co-efficient of static friction between the masses and the surface is constant).
Then the correct statement of the following is



(a) M_3 begins to slide at a higher inclination angle than M_1 & M_2
(b) M_3 begins to slide at a lower inclination angle than M_1 & M_2
(c) M_1, M_2 & M_3 begins to slide at the same inclination angle
(d) M_2 begins to slide at a higher inclination angle than M_1 & M_3

AP EAMCET-07.07.2022, Shift-I

Ans. (c) : Condition, $M_1 > M_2 > M_3$
θ → Angle of inclination
μ → co-efficient of static frication



For object (1),

$$R_1 = M_1g\cos\theta \quad \text{.....(i)}$$

And

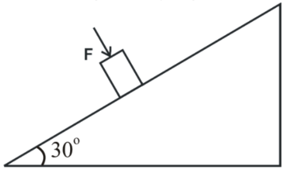
$$M_1g\sin\theta = \mu R_1$$

$$M_1g\sin\theta = \mu M_1g\cos\theta \quad \text{[from equation (i)]}$$

$$\mu = \tan\theta$$

Similarly for object (2) & (3)
Hence, M_1, M_2 & M_3 beings to slide at the same inclination angle.

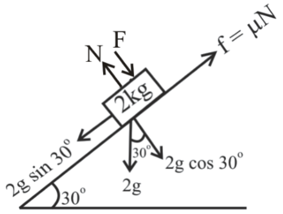
488. A box of mass 2kg is placed on a inclined plane that makes 30^0 with the horizontal. The coefficient of friction between the box and inclined plane is 0.2. A force F is applied on the box perpendicular to the incline to prevent the box from sliding down. The minimum value of F is–
(acceleration due to gravity (g) = 10 ms^{-2})



(a) 28.6 N (b) 22.8 N
(c) 32.7 N (d) 44.6 N

AP EAMCET-07.07.2022, Shift-II

Ans. (c) : Given,
m = 2kg, μ = 0.2
From the figure,



From the figure

$$2g\sin 30^\circ = \mu N$$

@apna_pdf

$$2\times10\times\frac{1}{2}=0.2\times N$$

$$N = 50\text{ N}$$

And

$$F + 2g\cos30^o = N$$

$$F = N - 2g\cos30^o$$

$$F = 50-2\times10\times\frac{\sqrt{3}}{2}$$

$$F = 50-10\sqrt{3}$$

$$F = 32.67\text{ N}$$

489. The coefficient of static friction between the road and tyres of a car is 0.4. The maximum permissible speed of the car is 10 ms^{-1} on curved unbanked road. Then the maximum radius of curvature of the road is (acceleration due to gravity = 10 ms^{-2})

(a) $10\sqrt{5}$ m
(b) 25 m
(c) $20\sqrt{2}$ m
(d) 30 m

AP EAMCET-06.07.2022, Shift-I

Ans. (b) : Given,
Static friction = 0.4, v_{max} = 10m/s
We know,
Frictional force = centripetal force

$$\mu mg = \frac{mv^2}{R}$$

$$\boxed{v^2 = \mu gR}$$

Where
μ = coefficient of friction between car and tyre
R = Radius of curve
v = velocity of a car

$$(10)^2 = 0.4\times10\times R$$

$$R = \frac{10\times10}{10\times0.4} = \frac{100}{4}$$

$$\boxed{R = 25\text{m}}$$

Hence, the maximum radius of curvature of the road is 25m.

490. The coefficient of friction between object and substance, if we need to move an object of weight 150 N on a horizontal surface with a force of 75 N. is

(a) 0.8
(b) 0.5
(c) 0.7
(d) 0.9

AP EAMCET-06.07.2022, Shift-I

Ans. (b) : Given, Weight = 150 N,
Horizontal force = 75 N
We know
The friction force = $f = \mu N$ and N = weight= 150 N
Where,
μ = coefficient of friction between the surfaces in contact
N = normal force perpendicular to friction force
So, $75 = \mu \times 150$

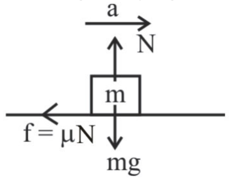
$$\mu = \frac{75}{150} = 0.5$$

491. A block is lying at rest inside a bus. The maximum acceleration of the bus such that the block remain stationary (the static friction coefficient = 0.2, acceleration due to gravity = 10ms^{-2})

(a) 1 ms^{-2}
(b) 0.5 ms^{-2}
(c) 2 cm s^{-2}
(d) 2 ms^{-2}

AP EAMCET-08.07.2022, Shift-II

Ans. (d) : Let the mass of the block is m,
Friction (μ) = 0.2
And acceleration due to gravity (g) = 10 m/sec^2



Resolving the force
$\Sigma F_y = 0$

$$N = mg \qquad \ldots\ldots(i)$$

And $\Sigma F_x = 0$

$$\mu N = ma\ldots\ldots(ii)$$

From equation (i) and (ii)

$$\mu mg = ma$$

$$a = \mu g$$

$$a = 0.2\times10$$

$$a = 2\text{ m /sec}^2$$

492. A circular race track of radius 240 m is banked at an angle of 45°. If the coefficient of friction between the wheels of a race car and the rod is 0.2, the maximum permissible speed to avoid slipping is [Acceleration due to gravity=10 m/s^2]

(a) 40m s^{-1}
(b) 60m s^{-1}
(c) 72 m s^{-1}
(d) 50m s^{-1}

AP EAMCET-11.07.2022, Shift-I

Ans. (b) : Given,
r = 240,
g = 10 m/s^2
θ = 45° then, tan 45° = 1 and friction (μ_s) = 0.2
Then maximum permissible speed to avoid slipping V_{max} is

$$V_{max} = \sqrt{\frac{rg(\mu_s+\tan\theta)}{1-\mu_s\tan\theta}}$$

$$V_{max} = \sqrt{\frac{240\times10(0.2+1)}{1-0.2\times1}} = \sqrt{\frac{2400\times1.2}{0.8}}$$

$$= \sqrt{300\times12}$$

$$= \sqrt{3600}$$

V_{max}= 60 m/s

493. Which is true for rolling friction (μ_r), static friction (μ_s) and kinetic friction (μ_k):

(a) $\mu_s > \mu_k > \mu_r$
(b) $\mu_s < \mu_k < \mu_r$
(c) $\mu_s < \mu_k < \mu_r$
(d) $\mu_s > \mu_r < \mu_k$

AP EAMCET-07.07.2022 Shift-II
JIPMER-2006

@apna_pdf

Ans. (a) : Kinetic friction is a moving friction and as a result only a little amount of force is required. Hence, static friction is always greater than kinetic friction Thus, $\mu_s > \mu_k$.

The rolling friction is the force just resisting the motion when a body (such as a ball, tyre, or wheel) rolls on a surface. It is very small resisting force than the other two friction.

Therefore, $\mu_s > \mu_k > \mu_r$

494. A bag is gently dropped on a conveyor belt moving at a speed of 2 m/s. The coefficient of friction between the conveyor belt and bag is 0.4. Initially, the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion is: [Take g = 10 ms^{-2}]

(a) 2 m (b) 0.5 m
(c) 3.2 m (d) 0.8 m

JEE Main-27.07.2022, Shift-I

Ans. (b) : Given, v = 2 m/s, $\mu = 0.4$

$\because \quad f = \mu R$

$ma = \mu R$

$ma = \mu mg$

$a = \mu g$

From third equation of motion

$v^2 = u^2 + 2as$

Since the box finally comes to rest, v = 0 and we need to find distance 's'. Also, the bag is decelerating so 'a' is negative.

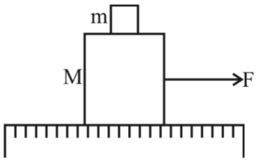
$\therefore \quad (0)^2 = (2)^2 - 2as$

or $\quad -4 = -2 \times (\mu g) \times s$

$2 = 0.4 \times 10 \times s$

$s = 0.5$ m

495. A system of two blocks of masses m= 2 kg and M = 8 kg is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be



(a) 9.8 N (b) 39.2 N
(c) 49 N (d) 78.4 N

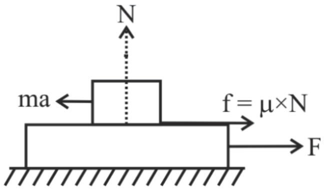
JEE Main-27.06.2022, Shift-I

Ans. (c) : Given,

$\mu = 0.5$ (b/w both block)

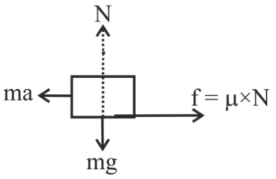
$m = 2$ kg

$m = 8$ kg



If both block is moving together with acceleration "a" by applying force F

FBD for block of 2 kg mass



$ma = f$ (for together movement of m and M)

$ma = \mu N$

$ma = \mu mg$

$a = \mu g$

For both block M and m

$F = (M+m)\,a$

$F = (8+2) \times \mu g$

$F = 10 \times 0.5 \times 9.8$

$F = 49$ N

496. A block of mass 10 kg starts sliding on a surface with an initial velocity of 9.8 ms^{-1}. The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest is: [use g = 9.8 ms^{-2}]

(a) 4.9 m (b) 9.8 m
(c) 12.5 m (d) 19.6 m

JEE Main-24.06.2022, Shift-I

Ans. (b) : Given,

The coefficient of friction between the surface and block is 0.5

$g = 9.8$ m/s^2, $u = 9.8$ m/s , $v = 0$ m/s

So, retardation (a) = μ g

$= 0.5 \times 9.8$

$= 4.9$ m/s^2

$\therefore$ Distance (s) covered by the block before coming to rest is–

$v^2 = u^2 - 2as$

$$s = \frac{u^2}{2a} = \frac{(9.8)^2}{2 \times 4.9}$$

$s = 9.8$m

497. A uniform chain of 6 m length is placed on a table such that a part of its length is hanging over the edge of the table. The system is at rest. The co-efficient of static friction between the chain and the surface of the table is 0.5, the maximum length of the chain hanging from the table is ______ m.

JEE Main-25.06.2022, Shift-I

Ans. (2) : Given,

L = 6m

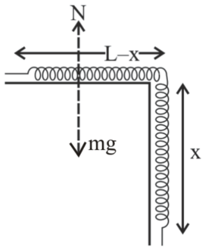
System is at rest and the co-efficient of static friction between the chain and surface of the table is $\mu_s = 0.5$

Let x be the hanging length of the chain then.

$N = mg = \lambda(L-x)\,g.$

$\lambda \to$ mass per unit length of chain

@apna_pdf



Friction force

$$\therefore F_s = \mu_s \times \lambda (L-x) g$$

And also $F_s = \lambda x g$

$$0.5 \lambda (L-x) g = \lambda x g$$

$$\frac{L-x}{2} = x$$

$$\frac{L}{2} - \frac{x}{2} = x, \qquad \frac{L}{2} = x + \frac{x}{2}$$

$$\frac{L}{2} = \frac{3x}{2}, \qquad \frac{6}{2} = \frac{3x}{2}$$

$$x = 2\text{m}$$

So, maximum hanging length of chain = 2m

498. A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be _________ m/s.

JEE Main-25.06.2022, Shift-II

Ans. (24.00) : Given,

radius $(R_1) = 75$ m

Maximum speed $(v_1) = 30$ m/s

The changed radius of curved road $(R_2) = 48$ m

F_{max} will be equal to the centripetal force then

$$F_{max} = \frac{Mv^2}{R}$$

$$\mu Mg = \frac{Mv^2}{R}$$

$$\mu g = \frac{v^2}{R}$$

$$v^2 = \mu g \times R$$

$$v = \sqrt{\mu g R}$$

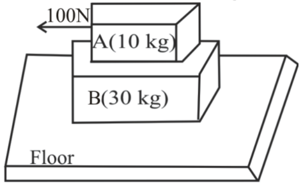
Since the coefficient of friction between the tyres and the road remain the same

$$\frac{v_2}{v_1} = \sqrt{\frac{R_2}{R_1}}$$

$$\frac{v_2}{30} = \sqrt{\frac{48}{75}}$$

$$v_2 = 24 \text{ m/s.}$$

499. A 30 kg slab B rests on a frictionless floor as shown in the figure. A 10 kg block A rests on top of the slab-B The coefficients of static and kinetic friction between the block A and the slab B are 0.60 and 0.40 respectively. When block - A is acted upon by a horizontal force of 100N, as shown, find the resulting acceleration of the slab- B ($g = 9.8 m.s^{-2}$)



(a) 0.98 m.s^{-2}
(b) 1.47 m.s^{-2}
(c) 1.52 m.s^{-2}
(d) 1.31 m.s^{-2}

AP EAMCET-20.08.2021, Shift-II

Ans. (d) : Let us first analyze if these blocks move together for that we will find the acceleration of the total mass (30+10) kg first.

Using formula F= ma or $a = \frac{F}{M} = \frac{100\text{N}}{40\text{kg}} = 2.5\text{m/sec}^2$

The acceleration is 2.5 m/s^2 and the maximum frictional force $= \mu_s \times N$

$$= \mu_s \times m.g$$

$$= (0.60)(10)(9{\cdot}8) = 58.8 \text{ N}$$

Thus, it is clear that frictional force smaller than the applied force and proves that the block and the slab move respect to each other.

For block B the actual friction force, $f = \mu mg$

$$= 0.4 \times 10 \times 9.8$$

$$= 39.2 \text{ N}$$

Resulting acceleration of the slab-B, a = f/m

$$= \frac{39.2}{30}$$

$$= 1.306$$

$$a = 1{\cdot}31 \text{ m.s}^{-2}$$

500. A coefficient of static friction for steel on ice is 0.1. The coefficient of the sliding friction therefore can be

(a) 0.1
(b) 0.11
(c) 0.01
(d) 1.1

CG PET-2021

Ans. (c) : Coefficient of static friction is always greater than the coefficient of kinetic friction.

$$\mu_s > \mu_k \text{ or } \mu_k < \mu_s$$

So, the coefficient of the sliding friction is 0.01.

501. A uniform chain has a mass 'm' and length '*l*'. It is held on a frictionless table with one-sixth of its length hanging over the edge. The work done in just pulling the hanging part back on the table is:

(a) $\frac{mgl}{72}$
(b) $\frac{mgl}{36}$
(c) $\frac{mgl}{12}$
(d) $\frac{mgl}{6}$

AP EAMCET-20.08.2021, Shift-I

@apna_pdf

Ans. (a) : Given, length of chain = l, mass of the chain = m, hanging part of the chain = $l/6$

Let F be the force required to lift the hanging

$\because$ dW = F.dx

$$dW = \frac{mgx}{l}dx \qquad \left(\because F = \frac{mgx}{l}\right)$$

Integrating both side –

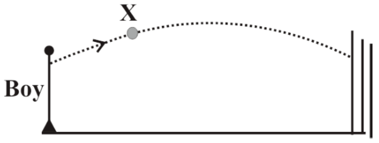
$$\int_0^W dW = \int_0^{l/6} \frac{mgx}{l} dx$$

$$W = \frac{mg}{l} \cdot \left[\frac{x^2}{2}\right]_0^{l/6}$$

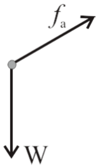
$$W = \frac{mg}{l} \cdot \frac{l^2}{36 \times 2}$$

$$W = \frac{mgl}{72}$$

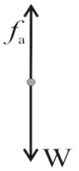
502. A boy throws a cricket ball from the boundary to the wicket keeper. If the frictional force due to air (f_a) cannot be ignored, the forces acting on the ball at the position X are represented by



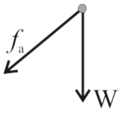
(a)



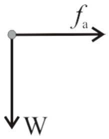
(b)



(c)

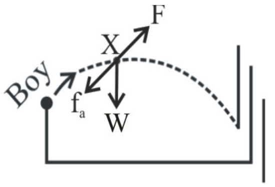


(d)



AP EAMCET-20.08.2021, Shift-I
Karnataka CET-2010

Ans. (c): Given, friction force due to air = f_a

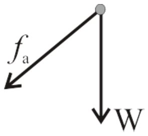


According to given diagram

Let weight of ball is W.

As, we know that, weight w is always perpendicular toward earth and friction force f_a is always in opposite direction of net force.

$\therefore$ Free body diagram of ball will be option (c).

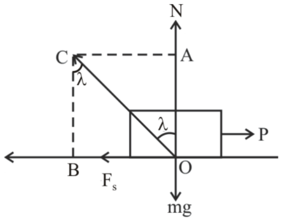


503. The coefficient of friction 'μ' and the angle of friction 'λ' are related by____

(a) $\tan\lambda = \mu$ (b) $\cos\lambda = \mu$
(c) $\sin\lambda = \mu$ (d) $\cos\mu = \lambda$

AP EAMCET-03.09.2021, Shift-II

Ans. (a) :



In ΔAOC, $\tan\lambda = \frac{AC}{OA} = \frac{OB}{OA}$

$$\tan\lambda = \frac{F_s}{N} = \frac{\mu N}{N} \qquad (\because \quad F_s = \mu N)$$

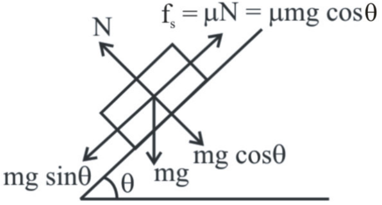
Hence, $\mu = \tan\lambda$

504. When a body is placed on a rough plane (coefficient of friction = μ) inclined at an angle θ to the horizontal, its acceleration is____(acceleration due to gravity = g)

(a) g (sinθ – μcosθ)
(b) g (sinθ – cosθ)
(c) gμ (sinθ – cosθ)
(d) g (μsinθ – cosθ)

AP EAMCET-19.08.2021, Shift-I

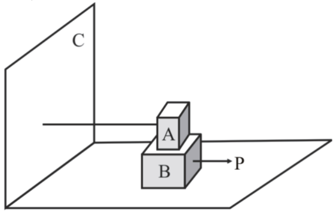
Ans. (a): According to the figure-



The body is sliding down, then -

$$mg\sin\theta - \mu\, mg\cos\theta = ma$$
$$a = g\sin\theta - \mu g\cos\theta$$
$$a = g(\sin\theta - \mu\cos\theta)$$

505. A block 'A' of mass 100 kg is kept above another block 'B' of mass 300 kg. 'A' is tied to the wall 'C' with a horizontal string. The coefficient of friction between 'A' and 'B' is 0.35 and that between 'B' and the horizontal surface is 0.5 Find the horizontal force P. necessary to move block 'B'.



(a) 1150 N (b) 1250 N
(c) 2350 N (d) 1420 N

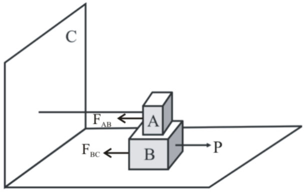
AP EAMCET-25.08.2021, Shift-I
UPSEE - 2009

@apna_pdf

Ans. (c) : Given,

$m_A = 100\text{kg}$, $m_B = 300\text{kg}$

$\mu_{AB} = 0.35$, $\mu_{BC} = 0.5$



From figure,

$$P = F_{AB} + F_{BC}$$
$$P = \mu_{AB} \,.\, m_A \,.\, g + \mu_{BC}(m_A + m_B)g$$
$$P = 0.35 \times 100 \times 10 + 0.5\,(100 + 300) \times 10$$
$$P = 350 + 2000$$
$$P = 2350\text{ N}$$

506. A solid cylinder of mass 'm' and radius 'r' starts rolling down an inclined plane of inclination θ. If the friction is just enough to prevent slipping, the speed of its centre of mass after it has descended through a height 'h' is given by ______

(a) $\sqrt{\frac{4}{3}gh}$ (b) $\sqrt{\frac{4gh}{3}}$

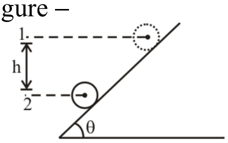
(c) $\frac{3}{4}gh$ (d) $\sqrt{\frac{3gh}{4}}$

AP EAMCET-03.09.2021, Shift-I

Ans. (b) : For pure rolling, total mechanical energy will be conserved.

Friction work = 0 (zero)

From figure –



Energy at position 1, $(E_1) = mgh$

Energy at position 2,

$$E_2 = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$$

$$\because \frac{v_{cm}}{r} = \omega \text{ and } I_{cm} = \frac{mr^2}{2}$$

$$\therefore \quad E_2 = \frac{1}{2}m \times r^2\omega^2 + \frac{1}{2}\frac{mr^2}{2}\omega^2$$

$$E_2 = \frac{1}{2}mr^2\omega^2 + \frac{1}{4}mr^2\omega^2$$

$$E_2 = \frac{3}{4}mr^2\omega^2$$

$$E_2 = \frac{3}{4}mv_{cm}^2 \qquad (\because v_{cm} = r\omega)$$

From law of conservation of energy $E_1 = E_2$

$$mgh = \frac{3}{4}mv_{cm}^2$$

$$v_{cm}^2 = \frac{4}{3}gh$$

$$v_{cm} = \sqrt{\frac{4}{3}gh}$$

507. A motor cyclist wants to drive in horizontal circles on the vertical inner surface of a large cylindrical wooden well of radius 8.0m with minimum speed of $5\sqrt{5}\text{m.s}^{-1}$. The minimum value of coefficient of friction between the tires and the wall of the well must be ——— $(g = 10\text{ m.s}^{-2})$

(a) 0.10 (b) 0.64

(c) 0.30 (d) 0.40

AP EAMCET-19.08.2021, Shift-II

Ans. (b): Given that-

Radius of wooden well = 8.0 m

Minimum speed = $5\sqrt{5}\text{ m.s}^{-1}$

Friction force, $f_s = mg$

Centripetal force, $N = \frac{mv^2}{r}$

We know,

$$\mu = \frac{f_s}{N}$$

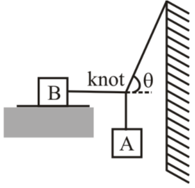
$$\therefore \quad \mu = \frac{mg}{\frac{mv^2}{r}}$$

$$\mu = \frac{rg}{v^2}, \qquad \mu = \frac{8 \times 10}{\left(5\sqrt{5}\right)^2}$$

$$\mu = \frac{80}{125}$$

$$\mu = 0.64$$

508. A block B, lying on a table, weighs 'W'. The coefficient of static friction between the block and the table is μ. Assume that the cord between B and the knot is horizontal. The maximum weight of the block A for which the system will be stationary is ________.

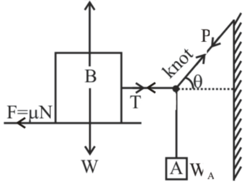


(a) $\frac{W\tan\theta}{\mu}$ (b) $\mu W\tan\theta$

(c) $\mu W\sqrt{1+\tan^2\theta}$ (d) $\mu W\sin\theta$

AP EAMCET-23.08.2021, Shift-II

Ans. (b) :



The block B is under equilibrium by action of tension force 'T'

Hence T= μN and N=W

So, T = μN = μW

@apna_pdf

At knot applying lami's theorem

$$\frac{T}{\sin(90^\circ+\theta)}=\frac{W_A}{\sin(180^\circ-\theta)}=\frac{P}{\sin 90^\circ}$$

$$\frac{T}{\cos\theta}=\frac{W_A}{\sin\theta}=\frac{P}{1}$$

$$\therefore\ W_A=\frac{T\sin\theta}{\cos\theta}=T\tan\theta$$

$W_A = \mu W \tan\theta \quad \{\because\ T=\mu W\}$

509. A solid flywheel of mass 20 kg and radius 120 mm revolves at 600 rpm. Find the total force that must applied by the brake so that the flywheel stop in 3 seconds. Given the coefficient of friction between the wheels and brake lining is 0.1.

(a) 80π N (b) 24π N
(c) 70π N (d) 60π N

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (a) : Given that,
Speed n = 600 rpm

Moment of inertia $I=\frac{1}{2}mR^2$

Radius R = 120 mm = 0.12 m
Mass m = 20 kg
Coefficient of friction $\mu = 0.1$

Angular speed $(\omega)=\frac{2\pi n}{60}=\frac{2\times\pi\times600}{60}=20\pi\,\text{red/sec}$

Angular acceleration $(\alpha)=\frac{\Delta\omega}{\Delta t}=\frac{\omega}{t}=\frac{20\pi}{3}=\frac{20}{3}\pi\,\text{red/s}^2$

Further, torque $\tau = I\alpha$
Here, $\mu F.R = I\alpha$

$$F=\frac{I\alpha}{\mu R}$$

$$F=\frac{\frac{1}{2}mR^2\times\frac{20\pi}{3}}{\mu R}$$

Or force, $F=\frac{10\pi mR}{3\mu}$

Substituting the value, we get-

$$F=\frac{10\pi\times20\times0.12}{3\times0.1}$$

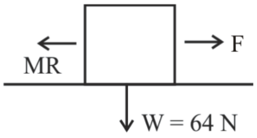
$$F=80\pi N$$

510. A body of weight 64 N is pushed with just enough force to start it moving across a horizontal floor and the same force continues to act afterwards. If the coefficients of static and dynamic frictions are 0.8 and 0.6 respectively, the acceleration of the body will be _____

(a) 0.2 g (b) $\frac{g}{32}$
(c) 0.64 g (d) $\frac{g}{6.4}$

AP EAMCET-25.08.2021, Shift-II

Ans. (a) :



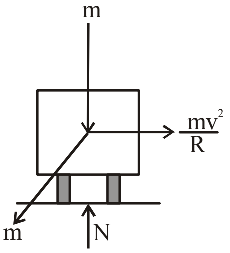
Given, μ_s = static friction = 0.8
μ_d = dynamic friction = 0.6
The total force (f)ma = mg $(\mu_s - \mu_d)$
ma = mg (0.8 – 0.6)
a = 0.2 g

511. A car moves on a horizontal circular road of radius 16 m with increasing speed at a constant rate of 3 m/s^2. If the coefficient of friction between the road and tyre is 0.5, then the minimum speed at which the car will skid is (assume g = 10 m/s^2)

(a) 5 m/s (b) 10 m/s
(c) 16 m/s (d) 8 m/s

TS EAMCET 04.08.2021, Shift-II

Ans. (d) : Given,
Increasing speed at a constant rate = 3 m/s^2
Coefficient of friction between the road & tyre (μ)= 0.5
g = 10 m/sec^2
A car moves on a horizontal road of radius R = 16 m



It has two acceleration,

tangential acceleration $(a_t)=\frac{dv}{dt}=3$

radial acceleration $(a_r)=\frac{v^2}{R}$

$$a_r=\frac{v^2}{R}$$

$$a_{net}=\sqrt{\left(\frac{v^2}{R}\right)^2+3^2}=\sqrt{\frac{v^4}{R^2}+9}\quad\left(\because a_{net}=\sqrt{a_r^2+a_t^2}\right)$$

$\therefore\quad \mu N = ma_{net}$

Where, N is normal reaction.

$$\mu N = m\sqrt{\frac{v^4}{R^2}+9}$$

$$\mu g=\sqrt{\frac{v^4}{R^2}+9}$$

Squaring on both side, we get-

$$(0.5\times10)^2=\frac{v^4}{256}+9$$

@apna_pdf

$$(5)^2 = \frac{v^4}{256} + 9$$

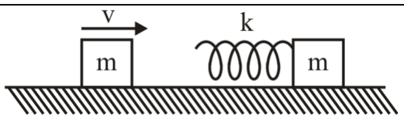
$$25 - 9 = \frac{v^4}{256}$$

$v^4 = 16 \times 256$

$v^4 = 2^4 \times 4^4$

$v = 2 \times 4 = 8$ m/sec

512.



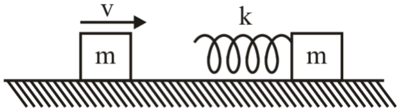
A block of mass m slides with speed v on a frictionless table towards another stationary block of mass m. A massless spring with spring constant k is attached to the second block as shown in figure. The maximum distance the spring gets compressed through is

(a) $\sqrt{\frac{m}{k}}\,v$ (b) $\sqrt{\frac{m}{2k}}\,v$

(c) $\sqrt{\frac{k}{m}}\,v$ (d) $\sqrt{\frac{k}{2m}}\,v$

WB JEE 2021

Ans. (a) :



The kinetic energy of sliding block = $\frac{1}{2}mv^2$.

Let, the spring compressed by an amount of x m.

$\therefore$ Potential energy of the spring = $\frac{1}{2}kx^2$

Equating there two energies, we get,

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$\Rightarrow \quad mv^2 = kx^2$

$\Rightarrow \quad x^2 = \frac{mv^2}{k}$

$\therefore \quad x = v\sqrt{\frac{m}{k}}$

513. A wooden block of mass 10 kg is moving with an acceleration of $3ms^{-2}$ on a rough floor. If the coefficient of friction is 0.3, then the applied force on it is ($g = 10ms^{-2}$)

(a) 10 N (b) 30 N

(c) 80 N (d) 60 N

(e) 65 N

Kerala CEE 2021

Ans. (d) : $f = \mu N$

$f = \mu mg$

$= 0.3 \times 10 \times 10 = 30\,N$

$F - f = ma$

$F - 30 = 10 \times 3$

$F = 60$ N

514. Frictional force increases when surfaces in contact are made very smooth. This is because:

(a) of molecular forces

(b) of decrease in surface area

(c) of decrease in irregularities

(d) increases in area

AP EAMCET-23.09.2020, Shift-II

Ans. (a): Frictional force increases when surfaces in contact are made very smooth because inter molecular forces between surfaces increases and it gives rise to friction.

515. If the coefficient of friction between the rubber tires and the road way is 0.25. Find the maximum speed with which a car can be driven round a curve of radius 20 m without skidding. Given, $g = 9.8\ m.s^{-2}$:

(a) $5\ m.s^{-1}$ (b) $7\ m.s^{-1}$

(c) $10\ m.s^{-1}$ (d) $14\ m.s^{-1}$

AP EAMCET-25.09.2020, Shift-I

Ans. (b) : Given,

$\mu = 0.25$

$r = 20$ m

$g = 9.8\ m/sec^2$

To find velocity in the equilibrium

$$v = \sqrt{\mu rg} = \sqrt{0.25 \times 20 \times 9.8}$$

$$v = \sqrt{49} = 7 m.s^{-1}$$

516. Vehicles are streamlined to reduce _______

(a) Static friction (b) Kinetic friction

(c) Sliding friction (d) Fluid friction

AP EAMCET-24.09.2020, Shift-II

Ans. (d) : A streamlined shape is a shape that reduces friction drag between fluid such as air or water and an object moving through it.

So, vehicles have streamlined shape to reduce fluid friction.

517. Friction can perform ________

(a) Positive work only

(b) Zero work only

(c) Negative work only

(d) Positive, negative and zero work

AP EAMCET (Medical)-07.10.2020, Shift-I

Ans. (d) : Friction can perform is work done by friction may be positive, negative and zero work.

When frictional force is opposite to direction the work is negative.

When friction force is in same direction of displacement work is positive and if there is no displacement then work is zero.

518. A cylinder rolls down on inclined plane of inclination 30°, the acceleration of the cylinder is

(a) $\frac{g}{3}$ (b) g

(c) $\frac{g}{2}$ (d) $\frac{2g}{3}$

AP EAMCET (Medical)-07.10.2020, Shift-I

@apna_pdf

Ans. (a) : As we know that, acceleration of a cylinder rolls down on inclined plane.

$$a = \frac{g\sin\theta}{\left(1+\frac{I}{mR^2}\right)}$$

Where, I = moment of Inertia

$$\text{For solid cylinder, } I = \frac{mR^2}{2}$$

$$\text{Then,}\quad a = \frac{g\sin 30^\circ}{\left(1+\frac{mR^2}{2}\times\frac{1}{mR^2}\right)}$$

$$a = \frac{g\times 1/2}{1+1/2} = \frac{g}{3}$$

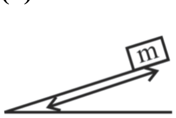
519. If time taken by a block to descend along a rough surface inclined at an angle 45° with horizontal is double that taken along a similar smooth surface, then coefficient of dynamic friction associated with the rough surface will be

(a) 0.25 (b) 0.5

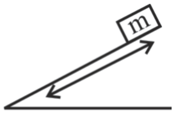
(c) 0.60 (d) 0.75

Tripura-2020

Ans. (d) :



rough surface
time t_1



smooth surface
time = t_2

$$\text{Given,}\quad \frac{t_1}{t_2} = 2$$

From velocity equation–

$$s = ut + \frac{1}{2}at^2$$

$$s = 0 + \frac{1}{2}at^2$$

$$a = \frac{2s}{t^2}$$

$$t = \sqrt{\frac{2s}{a}}$$

$$t \propto \sqrt{\frac{1}{a}}$$

$$\therefore \frac{t_1}{t_2} = \sqrt{\frac{a_2}{a_1}} \qquad \text{......(i)}$$

$$a_1 = g\sin\theta - \mu g\cos\theta \qquad \text{......(ii)}$$

$$a_2 = g\sin\theta \qquad \text{......(iii)}$$

Keep these values in equation (i)

$$\frac{t_1}{t_2} = \sqrt{\frac{g\sin\theta}{g\sin\theta - \mu g\cos\theta}}$$

$$2 = \sqrt{\frac{\sin\theta}{\sin\theta - \mu\cos\theta}}$$

$$\because \theta = 45^\circ$$

$$2 = \sqrt{\frac{1/\sqrt{2}}{1/\sqrt{2} - \mu\times 1/\sqrt{2}}}$$

$$4 = \frac{1}{1-\mu}$$

$$1-\mu = \frac{1}{4}$$

$$\mu = 1 - \frac{1}{4}$$

$$\mu = \frac{3}{4}$$

$$\boxed{\mu = 0.75}$$

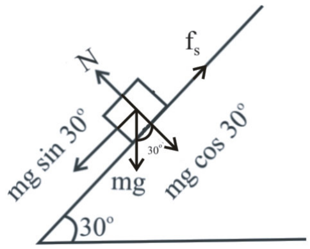
520. A block of mass 2kg rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is
(Assume $g = 10\ m/s^2$)

(a) 10N (b) $7\sqrt{3}$N

(c) $10\sqrt{3}$N (d) 7 N

TS EAMCET 29.09.2020, Shift-I

Ans. (b) :



According to question-

$$N = mg\cos 30^\circ$$

We know that,

$$f_s = \mu_s N$$

$$= \mu_s mg\cos 30^\circ$$

$$= 0.7\times 2\times 10\times\frac{\sqrt{3}}{2}$$

$$= 7\sqrt{3}\ \text{N}$$

521. A metallic block of mass 20 kg is dragged with a uniform velocity of 0.5 ms^{-1} on a horizontal table for 2.1 s. The coefficient of static friction between the block and the table is 0.10. What will be the maximum possible rise in temperature of the metal block, if the specific heat of the block is 0.1 CGS unit? Assume g = 10 ms^{-2} and uniform rise in temperature throughout the whole block. [Ignore absorption of heat by the table]

(a) 0.0025°C (b) 0.025°C

(c) 0.001°C (d) 0.05°C

WB JEE 2020

@apna_pdf

Ans. (a) : Given, m = 20 kg, v = 0.5 m/s

t = 2.1 sec, $\mu = 0.10$

We know that,

$$W = FS$$

$$W = (\mu mg)vt \qquad \{\because F = \mu mg\}$$

$$W = (0.1\times20\times10)\times0.5\times2.1$$

$$W = 20\times0.5\times2.1$$

$$W = 21J$$

$\because$ Work done = Heat energy

$\therefore$ Q = 21 J

Now, $Q = m.s.\Delta t$

$$Q = 20\times10^3\times0.1\times4.2\times\Delta t$$

$$21 = 20\times10^3\times0.1\times4.2\times\Delta t$$

$$\Delta t = \frac{21}{8400}$$

$$\Delta t = 0.0025°C$$

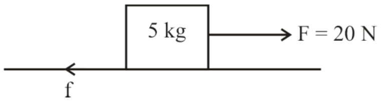
522. A force of 20 N is applied on a body of mass 5 kg resting on a horizontal plane. The body gains a kinetic energy of 10 J after it moves a distance 2 m. The frictional force is

(a) 10 N (b) 15 N

(c) 20 N (d) 30 N

COMEDK 2020

Ans. (b) :



Given that,

Kinetic Energy = 10 J

Distance (s) = 2m

m = 5 kg

Therefore, kinetic energy (K.E) = $\frac{1}{2}mv^2 = 10$

$$\frac{1}{2}\times5\times v^2 = 10$$

$$v^2 = \frac{10\times2}{5}$$

$$v^2 = 4$$

v = 2 m/sec.

According to third law of motion -

$\therefore$ $v^2 = u^2 + 2as$

$$(2)^2 = 0 + 2a\times2$$

$$4 = 2a\times2$$

$$4 = 4a$$

$$a = 1 \text{ m/sec}^2$$

In horizontal direction,

$$F = ma + f_s$$

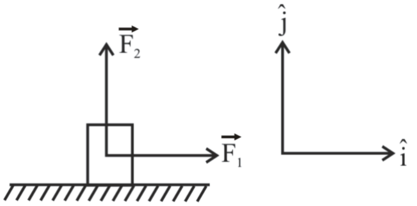
$$20 = 5(1) + f_s$$

$$f_s = 20 - 5$$

$$f_s = 15N$$

523. A block of mass m = 2 kg is initially at rest on a horizontal surface. A horizontal force $\vec{F}_1 = (6N)\hat{i}$ and a vertical force $\vec{F}_2 = (10N)\hat{j}$ are then applied to the block. The coefficients of static friction and kinetic friction for the block and the surfaces are 0.4 and 0.25, respectively. The magnitude of the frictional force acting on the block is

(assume, g = 10 m/s^2)



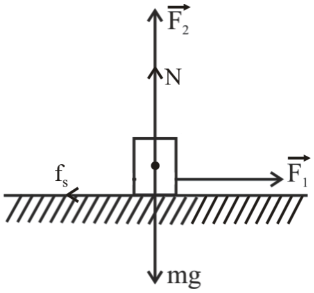
(a) 2.5 N (b) 4.0 N

(c) 3.3 N (d) 3.0 N

TS-EAMCET-11.09.2020, Shift-1

Ans. (a) : Given,

$F_2 = 10N$, m=2kg and g=10 ms^{-2}, $F_1 = 6$ N



From free body diagram -

$$F_2 + N - mg = 0$$

Putting the value of these, we get-

$$N = (2\times10) - 10 = 10N$$

Hence, static friction, $f_s = \mu_s N = 0.4\times10 = 4N$

$f_s < F_1$, Hence static friction is less than the horizontal applied force. So, block will move, i.e. we are dealing with kinetic friction.

The friction force (kinetic) acting on the body is

$$f_k = \mu_k\times N = 0.25\times10 = 2.5 \text{ N}$$

524. A block of mass m placed on a rough horizontal plane is pulled by a constant power P. The coefficient of friction between the block and the surface is μ. The maximum velocity of the block will be

(a) $\frac{\mu P}{mg}$ (b) $\frac{\mu \, mg}{p}$

(c) μmgP (d) $\frac{P}{\mu mg}$

TS-EAMCET-14.09.2020, Shift-1

Ans. (d) :

P = F.v (constant)

$F = f_k = \mu N = \mu mg$, $f_{net} = 0$ (net force on block becomes zero.)

It has maximum or terminal velocity.

$$P = f_k \, v_{max}$$

$$P = \mu mg \, v_{max}$$

$$v_{max} = \frac{P}{\mu mg}$$

@apna_pdf

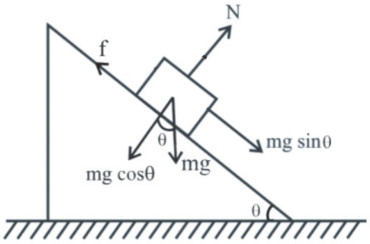
525. A block of mass 4 kg at rest on a rough inclined plane making an angle of θ with the horizontal. The coefficient of static friction between the block and plane is 0.5 and the frictional force on the block is 14.14 N, find the value of θ?

(a) 30^o (b) 45^o

(c) 60^o (d) 15^o

TS-EAMCET-14.09.2020, Shift-1

Ans. (b) :



Given,

$m = 4$ kg, $\mu_s = 0.5$, $f = 14.14$ N

Normal reaction force,

$$N = mg\cos\theta = 4 \times 10 \times \cos\theta = 40\cos\theta$$

friction, $f = \mu_s N$

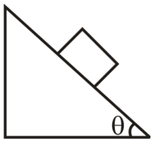
$$14.14 = 0.5 \times 40\cos\theta$$

$$\frac{14.14}{0.5 \times 40} = \cos\theta \Rightarrow \cos\theta = 0.707$$

$$\theta = \cos^{-1}(0.707)$$

$$\boxed{\theta = 45^o}$$

526. A block rests on a fixed wedge inclined at an angle θ. The coefficient of friction between the block and plane is μ. The maximum value of θ for the block to remain motionless on the wedge is



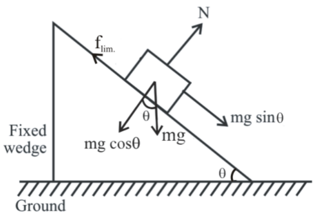
(a) $\mu = \tan\theta$ (b) $\mu = \sin\theta$

(c) $\mu = \cos\theta$ (d) $\mu = \cot\theta$

TS-EAMCET-14.09.2020, Shift-1

Ans. (a) : Suppose the mass of the block is m and acceleration due to gravity is g.

According to free body diagram-



Normal reaction (N) = mg cosθ

Limiting friction $(f_{lim}) = \mu N = \mu\, mg\cos\theta$

Net driving force $(F_{net\ driving}) = mg\sin\theta$

Then the block remain motionless on the wedge,

$$F_{net\ driving} \le f_{lim}$$

$$mg\sin\theta \le \mu\, mg\cos\theta$$

$$\sin\theta \le \mu\cos\theta$$

$$\tan\theta \le \mu \Rightarrow \tan\theta_{max} = \mu$$

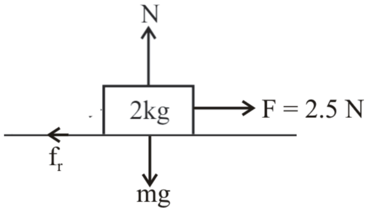
527. A body of mass 2 kg is placed on a horizontal surface having kinetic friction 0.4 and static friction 0.5. If the force applied on the body is 2.5 N, then the frictional force acting on the body will be [g = 10 ms^{-2}]

(a) 8 N (b) 10 N

(c) 20 N (d) 2.5 N

BITSAT-2020

Ans. (d) : Given, static friction $(\mu_s) = 0.5$ and kinetic friction $(\mu_k) = 0.4$



Resolving the forces along x and y direction

$\Sigma F_y = 0$

$$N = mg$$

$$N = 2 \times 10 = 20\text{ N}$$

Limiting friction force $f_r = \mu_s N = \mu_s mg$

$$f_r = 0.5 \times 2 \times 10$$

$$f_r = 10\text{N}$$

∵ Applied force on the body (F) = 2.5N

Hence, $F < f_r$

Friction force acting on body is more than the applied force. Hence, the frictional force acting on the body is 2.5 N

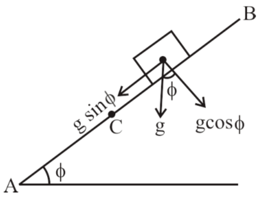
528. The upper half of an inclined plane with inclination ϕ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by

(a) 2 cos ϕ (b) 2 sin ϕ

(c) tan ϕ (d) 2 tan ϕ

BITSAT-2020

Ans. (d) :



Let AB = S and C is midpoint of AB

Then,

$$AC = BC = \frac{S}{2}$$

μ for BC = 0 (because of smooth surface)

And μ for AC = ?

@apna_pdf

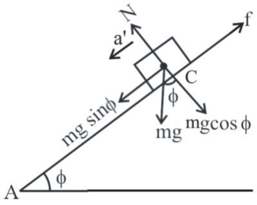
Using third law of motion, velocity at C

$$v^2 = u^2 + 2aS' \qquad \left(a = g\sin\phi \;,\; S' = \frac{S}{2}\right)$$

$$v^2 = 0 + 2g\sin\phi \times \frac{S}{2}$$

$$v^2 = S\,g\sin\phi \qquad \text{....(i)}$$

When block move between AC. Then Net downward acceleration is a' along inclined plane.



From the above figure

$$N = mg\cos\phi$$

and,

$$f = \mu N = \mu mg\cos\phi \qquad \text{...(ii)}$$

and,

$$mg\sin\phi - f = ma' \qquad \text{....(iii)}$$

From equation (ii) putting the value of 'f' in equation (iii)

Then,

$$mg\sin\phi - \mu mg\cos\phi = ma'$$

$$a' = g\sin\phi - \mu g\cos\phi \qquad \text{....(iv)}$$

From third equation of motion

$$v^2 = u^2 + 2a's$$

Here, $v = 0$, $a' = g\sin\phi - \mu g\cos\phi$, $s = \frac{S}{2}$, $u^2 = Sg\sin\phi$

Then, $0 = Sg\sin\phi + 2(g\sin\phi - \mu g\cos\phi)\frac{S}{2}$

$$2\,Sg\sin\phi = \mu\,Sg\cos\phi$$

$$2\sin\phi = \mu\cos\phi$$

$$2\frac{\sin\phi}{\cos\phi} = \mu$$

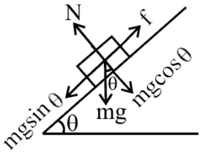
$$\mu = 2\tan\phi$$

529. If a block of mass 'm' place on a plane inclined at an angle θ, is on the verge of sliding, then the coefficient of friction between the block and the plane is given by

(a) sin θ
(b) cos θ
(c) tan θ
(d) (sin 2θ)/2

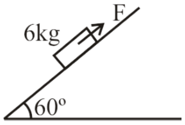
J&K-CET-2019

Ans. (c) : As the block is at rest all forces must be in equilibrium,



$N = mg\cos\theta$
$f = mg\sin\theta$
$\because f = \mu N$
$\therefore mg\sin\theta = \mu\, mg\cos\theta$
$\mu = \tan\theta$

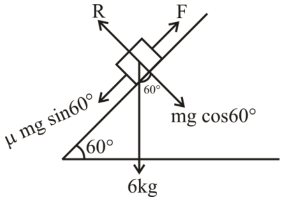
530. A 6.0 kg block is placed on a 60º ramp as shown in the figure. The coefficient of static friction is 0.6. A force $\vec{F}$ is applied that puts the block on the verge of sliding down the ramp. The value of force F in Newton is (Given: $\sqrt{3}$ = 1.73 and g = 9.8 m/s^2)



(a) 23
(b) 33
(c) 45
(d) 57

AMU-2019

Ans. (b) :



From figure-

$$F = \mu\, mg\sin 60°$$

∴ Given,

$m = 6$ kg
$\mu = 0.6$
$g = 9.8$
$\sqrt{3} = 1.73$

$$F = 0.6 \times 6 \times 9.8 \times \frac{\sqrt{3}}{2}$$

$$F = 17.64\sqrt{3}$$

$$F = 17.64 \times 1.73$$

$$F = 30.51 \approx 33$$

So, option (b) is correct.

531. For a truck with 14 tyres, only 8 rear wheels are power driven and can produce acceleration. These 8 wheels support half the entire load. If the coefficient of friction between road and each tyre is 0.6, the maximum attainable acceleration by this truck would be (Acceleration due to gravity = 10 ms^{-2})

(a) 6 ms^{-2}
(b) 3 ms^{-2}
(c) 10 ms^{-2}
(d) 24 ms^{-2}

AP EAMCET-23.04.2019, Shift-II

Ans. (b) : Given, $\mu = 0.6$, $g = 10$ m/s^2

Since 8 wheels support half of the entire load, therefore,

$$N = \frac{mg}{2} \qquad \text{......(i)}$$

Here, the acceleration is provided by friction therefore,

$$f = ma$$

$$f = ma = \mu N = \frac{\mu mg}{2} \qquad \text{[form equation (i)]}$$

$$\therefore \quad a = \frac{\mu g}{2}$$

$$a = \frac{0.6 \times 10}{2} = \frac{6}{2}$$

$$a = 3\ \text{m/s}^2$$

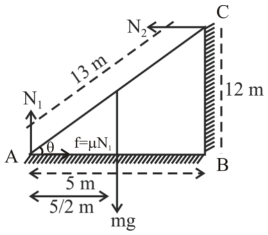
@apna_pdf

532. A 13 m ladder is placed against a smooth vertical wall its lower end at a distance 5 m from the wall. The minimum coefficient of friction between the ladder and the floor so that the ladder remains in equilibrium is nearly

(a) 0.52 (b) 0.72
(c) 0.21 (d) 0.36

AP EAMCET-23.04.2019, Shift-II

Ans. (c) :



∵ for ladder remains in equilibrium

$\sum F_y=0$

$N_1 = mg$ ……(i)

And, $\sum F_x = 0$

$N_2 = f = \mu N_1$ ……(ii)

taking moment about point A

$$N_2 \times 12 = mg \times \frac{5}{2}$$

$$N_2 = \frac{5\ mg}{24} \quad \text{…..(iii)}$$

From equation (ii) and (iii)

$$f = \frac{5 \times mg}{24}$$

$$\mu N_1 = \frac{5 \times mg}{24}$$

$$\mu\ mg = \frac{5}{24} \times mg$$

$$\mu = \frac{5}{24}$$

$\mu = 0.20833$

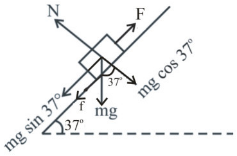
$\mu = 0.21$

533. A block of mass 100 kg attached to a mass less rope and the second end of the rope is pulled up by 2 men along a rough inclined plane of coefficient of friction 0.2 inclined at 37° with the horizontal. If they exert their maximum force for the block to just start moving up, the force exerted by each of them is.
(Acceleration due to gravity = 10 ms^{-2}, tan 37° ≈ 0.75)

(a) 500 N (b) 760 N
(c) 380 N (d) 250 N

AP EAMCET (Medical)-24.04.2019, Shift-I

Ans. (c) : Given, m = 100 kg, μ = 0.2, g = 10 m/s^2
tan θ = 37° = 0.75 = 3/4, sin37° = 3/5, cos37° = 4/5



Resolving the forces perpendicular to the plane

$N = mg \cos 37^\circ$

And we know,

$f = \mu N = \mu mg \cos\theta$ ……(i)

Resolving the forces parallel to the plane

$F = mg \sin 37^\circ + f$

$F = mg \sin 37^\circ + 0.2 \times mg \cos 37^\circ$

[From equation (i)]

Therefore, the force applied by each men-

$$F_{(\text{For each men})} = \frac{mg \sin 37^\circ + 0.2 \times mg \cos 37^\circ}{2}$$

$$= \frac{100 \times 10 \times \frac{3}{5} + 0.2 \times 100 \times 10 \times \frac{4}{5}}{2}$$

$= 300 + 80$

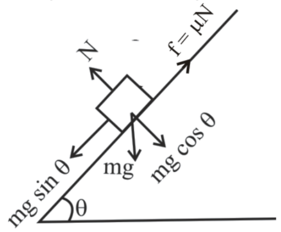
$= 380$ N

534. A body is sliding down a rough inclined plane of angle of inclination 0 for which the coefficient of friction varies with distance x as μ(x) = Kx, where k is a constant. Here x is the distance moved by the body down the inclined plane. If the net force on the body will be zero at a distance x$_o$. Then x$_o$ will be equal to

(a) $\frac{\tan\theta}{k}$ (b) k tanθ
(c) $\frac{\cot\theta}{k}$ (d) k cot θ

Assam CEE-2019

Ans. (a) : $f_{net} = mg \sin\theta - \mu mg \cos\theta$
$= mg \sin\theta - kxmg \cos\theta$



Where,

$f_{net} = 0, x = x_o$

$0 = mg \sin\theta - kx_o\ mg \cos\theta$

$mg (\sin\theta - kx_o \cos\theta) = 0$

$\sin\theta - kx_o \cos\theta = 0$

$$x_o = \frac{\sin\theta}{k\cos\theta}$$

$$x_o = \frac{\tan\theta}{k}$$

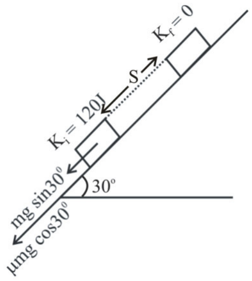
535. A 4.0 kg bundle starts up a 30° incline with 120 J of kinetic energy. The distance upto which the bundle will slide up the incline, if the coefficient of kinetic friction between the bundle and the incline in $\frac{1}{\sqrt{3}}$, is

(a) 6 m (b) 10 m
(c) 3 m (d) 8 m

TS EAMCET 08.05.2019, Shift-I

@apna_pdf

Ans. (c) :



$\because$ Work done = Change in KE (work-energy theorem)

$-mg\sin 30° \times S - \mu mg\cos 30° \times S = 0 - 120$

$$-4\times10\times\frac{1}{2}\times S-\frac{1}{\sqrt{3}}\times4\times10\times\frac{\sqrt{3}}{2}\times S=-120$$

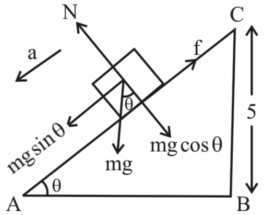
$$-20S-20S=-120$$
$$20S+20S=120$$
$$40S=120$$
$$S=\frac{120}{40}=3m$$
$$S=3m$$

536. A brick of mass 2 kg slides down an incline of height 5 m and angle 30°. If the coefficient of friction of the incline is $\frac{1}{2\sqrt{3}}$, the velocity of the block at the bottom of the incline is (Assume the acceleration due to gravity is 10 m/s^2)

(a) 5 m/s (b) 50 m/s
(c) 7 m/s (d) 0 m/s
(e) 10 m/s

Kerala CEE-2019

Ans. (c) : Given,
Mass of brick (m) = 2kg,
Height of plane (H) = 5m, Angle (θ) = 30°



Coefficient of friction $(\mu)=\frac{1}{2\sqrt{3}}$

$$ma = mg\sin\theta - f$$
$$ma = mg\sin\theta - \mu N$$
$$ma = mg\sin\theta - \mu mg\cos\theta$$
$$\therefore \quad a = g(\sin\theta - \mu\cos\theta)$$
$$a=10\left(\sin 30^o-\frac{1}{2\sqrt{3}}\times\cos 30^o\right)$$
$$a=10\times\left(\frac{1}{2}-\frac{1}{2\sqrt{3}}\times\frac{\sqrt{3}}{2}\right)$$
$$a=10\times\left(\frac{1}{2}-\frac{1}{4}\right)=\frac{10}{4}$$
$$a = 2.5\ m/s^2$$

Length of inclined Plane,

$$\sin\theta=\frac{BC}{AC}\Rightarrow\sin 30^o=\frac{5}{AC}$$
$$AC=\frac{5}{\sin 30^o}=10m$$
$$AC = s = 10\ m$$

From 3rd equation of motion-

$$v^2-u^2=2as$$
$$v=\sqrt{2as} \qquad (\because u=0)$$
$$v=\sqrt{2\times2.5\times10}$$
$$v=7.07m/s\approx7m/s$$

537. Which one of the following forces is non-central and non-conservative?

(a) Frictional force (b) Electric force
(c) Gravitational force (d) Mechanical force

NDA (I) 2019

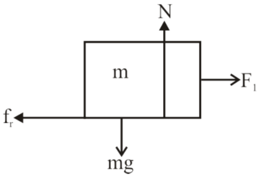
Ans : (a) Frictional force is non-central and non-conservative.

538. A body of mass m is kept on a rough horizontal surface (coefficient of friction=μ). Horizontal force is applied on the body, but it does not move. The resultant of normal reaction and the frictional force acting on the object is given F, where F is

(a) |F| = mg + μ mg (b) |F| = μmg
(c) $|F| \le mg\sqrt{1+\mu^2}$ (d) |F| = mg

NEET (Odisha) - 2019

Ans. (c) :



If $F_1 = 0$

By diagram –

$\mu N = \mu mg$ $[\because N=mg]$

Now contact force F will be

$$\sqrt{N^2+f_r^2}=\sqrt{(mg)^2+(\mu mg)^2}$$
$$\Rightarrow \quad F=mg\sqrt{1+\mu^2}$$

From above explanation we can say that force F will lie between,

$$F\le mg\sqrt{1+\mu^2}$$

539. A block of mass 10 kg is in contact against the inner wall of a hollow cylindrical drum of radius 1 m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be (g =10m/s^2)

@apna_pdf

(a) $\frac{10}{2\pi}\text{rad/s}$ (b) 10 rad/s

(c) 10π rad/s (d) $\sqrt{10}\text{rad/s}$

NEET (National) - 2019

Ans. (b) : For equilibrium of the block limiting friction

$f_L \geq mg$

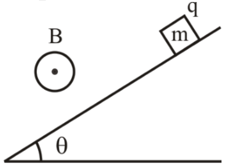
$\mu N \geq mg \qquad (\because N = mr\omega^2)$

$\mu\, mr\omega^2 \geq mg$

$$\omega \geq \sqrt{\frac{g}{r\mu}}$$

$$\omega_{min} = \sqrt{\frac{10}{0.1\times 1}} = 10 \text{ red/s}$$

540. A small block of mass 20 g and charge 4 mC is released on a long smooth inclined plane of inclination angle of 45°, A uniform horizontal magnetic field of 1 T is acting parallel to the surface, as shown in the figure. The time from the start when the block loses contact with the surface of the plane is



(a) 2 s (b) 3 s

(c) 5 s (d) 6 s

AP EAMCET (22.04.2019) Shift-I

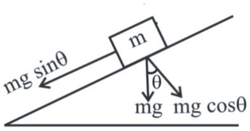
Ans. (c) : Given,

Mass of the block (m) = 20g = 0.02kg,

$q = 4mC = 4 \times 10^{-3}$ C, B = 1T

From equation of motion,

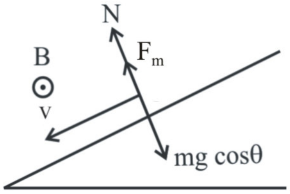
$v = g\sin\theta\, t \qquad ...(i)$



From magnetic field equation

$F_m = Bqv$

∵ This will lose contact with the surface of the place



$\therefore N = 0$

$F_m = mg\cos\theta$

$Bqv = mg\cos\theta$

$$v = \frac{mg\cos\theta}{B.q}$$

$$g\sin\theta\ t = \frac{mg\cos\theta}{B.q} \qquad [\text{From equation (i)}]$$

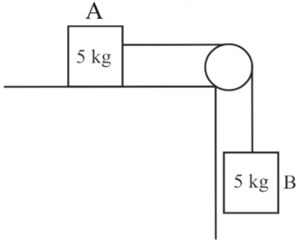
$$t = \frac{mg\cos\theta}{B.q\,g\sin\theta}$$

$$t = \frac{m}{B.q}\cot\theta$$

$$t = \frac{0.02}{1\times 4\times 10^{-3}}\times\cot 45^{\circ}$$

Time, $t = 5 \times 1 = 5$ second.

541. A block of mass 5 kg resting on a horizontal surface is connected by a cord, passing over a light frictionless pulley to a hanging block of mass 5 kg. The coefficient of kinetic friction between the block and the surface is 0.5. Tension in the cord is :(g=9.8m/sec^2)



(a) 49 N (b) Zero

(c) 36.75N (d) 2.45 N

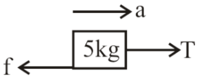
VITEEE-2019

Ans. (c) : Given,

Block of mass = 5 kg

$\mu = 0.5$

For block A –



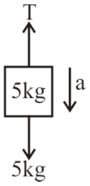
$T - f = ma$

$T - \mu mg = 5a$

$T - 0.5 \times 5 \times 9.8 = 5a$

$T = 5a + 0.5 \times 5 \times 9.8 \qquad ..... (i)$

For block B –



Block B is moving downward –

Hence,

$5g - T = 5a \qquad ...... (ii)$

From equation (i) and equation (ii), we get –

$5g - (5a + 0.5 \times 5 \times 9.8) = 5a$

$5g - 5a - 0.5 \times 5 \times 9.8 = 5a$

$5 \times 9.8 = 10a + 0.5 \times 5 \times 9.8$

$49 = 10a + 24.5$

$49 - 24.5 = 10a$

$24.5 = 10a$

$a = 2.45 \text{ m/s}^2$

From equation (ii) –

$5g - T = 5a$

$T = 5g - 5a = 5 \times 9.8 - 5 \times 2.45$

$T = 36.75$ N

@apna_pdf

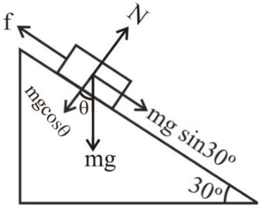
542. A body of 5 kg weight kept on a rough inclined plane of angle 30° starts sliding with a constant velocity. Then the coefficient of friction is (assume g = 10 m/s^2)

(a) $1/\sqrt{3}$ (b) $2/\sqrt{3}$

(c) $\sqrt{3}$ (d) $2\sqrt{3}$

AIIMS-26.05.2019(E) Shift-2

Ans. (a) : Given, m = 5 kg, θ = 30°, μ = ?



We know that,

$f_k = \mu N$

$= \mu.mg\cos\theta$ ....(i)

∵ Velocity is constant.

$a = \frac{dv}{dt} = 0$

$f_{net} = ma$

$f_{net} = 0$

When block is moving –

$mg\sin\theta - f_k = 0$

$f_k = mg\sin\theta$

Putting the value of f_k from equation (i), we get-

$\mu mg\cos\theta = mg\sin\theta$

Or $\frac{\sin\theta}{\cos\theta} = \mu$

$\mu = \tan\theta$ (θ = 30°)

$\mu = \tan 30°$ $\left(\tan 30° = \frac{1}{\sqrt{3}}\right)$

$\mu = \frac{1}{\sqrt{3}}$

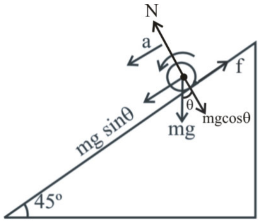
543. A uniform sphere of radius R and mass m is placed on an inclined plane which makes an angle 45° to the horizontal. For which of the following value of coefficient of friction, the sphere rolls without slipping.

(a) $\frac{3}{7}$ (b) $\frac{1}{2}$

(c) $\frac{5}{8}$ (d) $\frac{1}{7}$

TS-EAMCET-04.05.2019, Shift-2

Ans. (a,b,c) :



$ma = mg\sin\theta - f$ ....(i)

The linear acceleration of solid sphere,

$$a = \frac{g\sin\theta}{1+\frac{I}{mR^2}} = \frac{g\sin\theta}{1+\frac{2/5mR^2}{mR^2}} = \frac{5g\sin\theta}{7} \quad \left(\because I = \frac{2}{5}mR^2\right)$$

Substituting a value in equation (i),

$$\frac{5}{7}mg\sin\theta = mg\sin\theta - f$$

$$f = mg\sin\theta\left[1-\frac{5}{7}\right]$$

$$f = mg\sin\theta\left[\frac{7-5}{7}\right] = \frac{2}{7}mg\sin\theta \quad ....(ii)$$

From figure, N = mg cosθ ....(iii)

From coefficient of friction,

$$\mu_s = \frac{f}{N} = \frac{2/7\ mg\sin\theta}{mg\cos\theta} = \frac{2}{7}\tan\theta$$

For sphere rolls, without slipping,

$$\mu_s \geq \frac{2}{7}\tan\theta$$

$$\mu_s \geq \frac{2}{7}\tan 45°$$

$$\boxed{\mu_s \geq \frac{2}{7}}$$

Here, option (a), (b) and (c) is greater than 2/7.

Note: As per officially answer option (d).

544. Two touching blocks 1 and 2 are placed on an inclined plane forming an angle 60° with the horizontal. The masses are m_1 and m_2 and the coefficient of friction between the inclined plane and the two blocks are 1.5 μ and 1.0μ, respectively. The force of reaction between the blocks during the motion is (g = acceleration due to gravity)

(a) $(m_2 - m_1)\mu g$ (b) $(m_2 + m_1)\mu g$

(c) $\frac{1}{2}\frac{m_1m_2}{m_1+m_2}\mu g$ (d) $\frac{1}{4}\frac{m_1m_2}{m_1+m_2}\mu g$

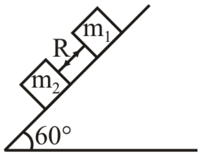
TS-EAMCET-03.05.2019, Shift-1

Ans. (d) : Given,

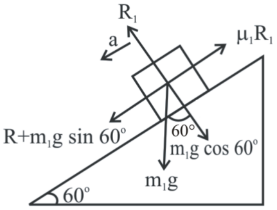
Coefficient of friction for first block (μ_1) = 1.5μ

Coefficient of friction for second block (μ_2) = 1μ

Acceleration of both block = a



Now, FBD for the first block,



@apna_pdf

If a be the common acceleration, then

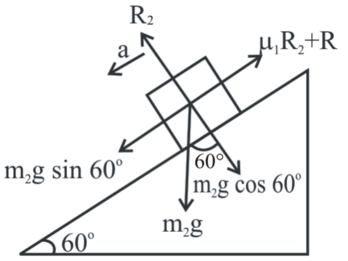
$$m_1 g\sin 60^\circ - \mu_1.R_1 + R = m_1 a$$

$$m_1 g\sin 60^\circ - 1.5\mu.m_1 g\cos 60^\circ + R = m_1 a$$

$$m_1 g\frac{\sqrt{3}}{2} - 1.5\mu m_1 g\times\frac{1}{2} + R = m_1 a$$

$$\frac{\sqrt{3}\,m_1 g}{2} - \frac{1.5\mu m_1 g}{2} + R = m_1 a \qquad ...(i)$$

Similarly, for second block,



Since, $m_2 g\sin 60^\circ - \mu_2 R_2 - R = m_2 a$

$$m_2 g\sin 60^\circ - \mu m_2 g\cos 60^\circ - R = m_2 a$$

$$\frac{\sqrt{3}\,m_2 g}{2} - \mu m_2 g\times\frac{1}{2} - R = m_2 a$$

$$\frac{\sqrt{3}\,m_2 g}{2} - \frac{\mu m_2 g}{2} - R = m_2 a \qquad ...(ii)$$

Dividing equation (i) by (ii), we get –

$$\frac{\frac{\sqrt{3}\,m_1 g}{2} - \frac{1.5\mu m_1 g}{2} + R}{\frac{\sqrt{3}\,m_2 g}{2} - \frac{\mu m_2 g}{2} - R} = \frac{m_1 a}{m_2 a}$$

$$\frac{\sqrt{3}\,m_1 g - 1.5\mu m_1 g + 2R}{\sqrt{3}\,m_2 g - \mu m_2 g - 2R} = \frac{m_1}{m_2}$$

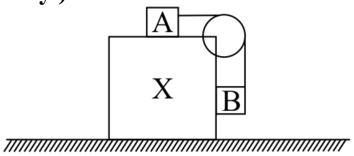
$$\sqrt{3}\,m_1 m_2 g - 1.5\mu m_1 m_2 g + 2Rm_2 = \sqrt{3}m_1 m_2 g - \mu m_1 m_2 g - 2Rm_1$$

$$2R(m_1 + m_2) = 0.5\ \mu m_1 m_2 g$$

$$R = \frac{\mu m_1 m_2 g}{4(m_1 + m_2)}$$

$$R = \frac{1}{4}\frac{m_1 m_2}{m_1 + m_2}\mu g$$

545. Consider a system of blocks X, A and B as shown in the figure. The blocks A and B have equal mass and are connected by a mass-less string through a mass-less pulley. The coefficient of friction between block A and X or B and X is 0.5. If block X moves on the horizontal frictionless surface what should be its minimum acceleration such that blocks A and B remain stationary, (g = acceleration due to gravity.)

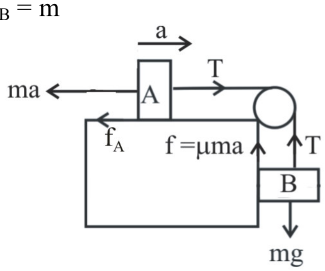


(a) $\frac{g}{3}$ (b) 3g

(c) $\frac{g}{4}$ (d) $\frac{3g}{4}$

TS-EAMCET-03.05.2019, Shift-1

Ans. (a) : Given that, μ = 0.5 , mass of block A and B, $m_A = m_B = m$



According to question, $ma + f_A = T$

$$ma + \mu mg = mg - \mu ma$$

$$m(a + \mu g) = m(g - \mu a)$$

$$a + \mu g = g - \mu a$$

$$a + \left(\frac{1}{2}\right)g = g - \left(\frac{1}{2}\right)a$$

$$a + \frac{a}{2} = g - \frac{g}{2}$$

$$\frac{2a + a}{2} = \frac{2g - g}{2}$$

$$3a = g$$

$$a = \frac{g}{3}$$

Hence, for stationary of block A and block B minimum acceleration is g/3.

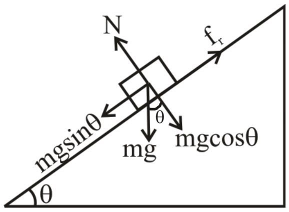
546. A block of mass 10 kg, initially at rest, makes a downward motion on 45° inclined plane. Then the distance travelled by the block after 2s is (Assume the coefficient of kinetic friction to be 0.3 and $g = 10\ ms^{-2}$)

(a) $7\sqrt{2}$m (b) $\frac{9}{\sqrt{2}}$m

(c) $10\sqrt{2}$m (d) $5\sqrt{2}$m

TS-EAMCET-04.05.2019, Shift-1

Ans. (a) : Given, m = 10 kg, θ = 45°, t = 2s, u = 0 m/s



From the figure,

$$ma = mg\sin\theta - \mu\,mg\cos\theta$$

$$a = g\sin\theta - \mu g\cos\theta$$

$$a = 10\frac{1}{\sqrt{2}} - 0.3\times 10\times\frac{1}{\sqrt{2}} \quad (\because \theta = 45^\circ)$$

$$a = \frac{10}{\sqrt{2}} - \frac{3}{\sqrt{2}} = \frac{7}{\sqrt{2}}ms^{-2}$$

@apna_pdf

Displacement of the block, from the second equation of the motion,

$$s = ut + \frac{1}{2}at^2$$

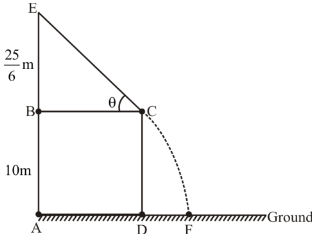
$$s = 0 \times t + \frac{1}{2}\ at^2 \qquad (\because u = 0)$$

$$s = \frac{1}{2} \times \frac{7}{\sqrt{2}} \times 2^2$$

$$s = 7\sqrt{2}\ \text{m}$$

547. A rough inclined plane BCE of height $\left(\frac{25}{6}\right)$m is kept on a rectangular wooden block ABCD of height 10 m, as shown in the figure. A small block is allowed to slide down from the top E of the inclined plane. The coefficient of kinetic friction between the block and the inclined plane is $\frac{1}{8}$ and the angle of inclination of the inclined plane is $\sin^{-1}(0.6)$. If the small block finally reaches the ground at a point F, then DF will be

(Acceleration due to gravity, $g = 10\ ms^{-2}$)



(a) $\frac{5}{3}$m (b) $\frac{10}{3}$m

(c) $\frac{13}{3}$m (d) $\frac{20}{3}$m

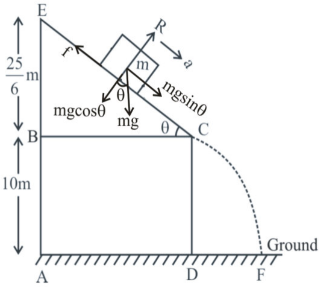
AP EAMCET (20.04.2019) Shift-1

Ans. (d) : Angle of inclination $\theta = \sin^{-1}(0.6)$

$$\sin\theta = 0.6$$

$$\cos\theta = \sqrt{1-\sin^2\theta} = \sqrt{1-(0.6)^2}$$

$$\cos\theta = 0.8$$



Given, $\mu_k = \frac{1}{8}$

Mass of block = m

Let, acceleration of mass = a

Block slide down therefore

Net force on block (downward)

$$R = mg\cos\theta$$

$mg\sin\theta - f = ma$ (downward)

$mg\sin\theta - \mu_k mg\cos\theta = ma$ $(\therefore f = \mu R)$

$g\sin\theta - \mu_k\ g\cos\theta = a$

$$10 \times 0.6 - \frac{1}{8} \times 10 \times 0.8 = a$$

$$6 - 1 = a$$

$$a = 5\ \text{m/sec}^2$$

Velocity of mass at point C

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2 \times 5 \times s$$

$v^2 = 10s$ $(\therefore u = 0$, velocity at E = 0)

Here, s = EC

In triangle ECB

$$\sin\theta = \frac{BE}{EC},\ \left(BE = \frac{25}{6}\right)$$

$$0.6 = \frac{\frac{25}{6}}{EC}$$

$$EC = \frac{25}{3.6}$$

$$\therefore \quad v^2 = 10s$$

$$v^2 = 10 \times \frac{25}{3.6} = 10 \times \frac{25}{36} \times 10$$

$$v = \frac{10 \times 5}{6} = \frac{25}{3}\text{m/s}$$

$$v = \frac{25}{3}\ \text{m/sec}$$

At point C we draw velocity component.

In vertical direction-

$$h = ut + \frac{1}{2}gt^2$$

here

$$h = 10$$

$$u = v\sin\theta = \frac{25}{3} \times 0.6$$

Then,

$$10 = \frac{25}{3} \times 0.6t + \frac{1}{2} \times 10 \times t^2$$

$$10 = 5t + 5t^2$$

$$t^2 + t - 2 = 0$$

$$(t + 2)(t - 1) = 0$$

$$t = 1\text{sec}$$

DF = (Horizontal component of velocity) × time

$$DF = v\cos\theta \times t$$

$$= \frac{25}{3} \times 0.8 \times 1$$

$$DF = \frac{20}{3}\ \text{m}$$

@apna_pdf

548. A body starts sliding down from the top of an inclined plane at an angle θ with the horizontal direction. The first one third of the incline is smooth, the next one third has coefficient of friction $\frac{\mu}{2}$ and the last one third has coefficient of friction $\frac{\mu}{2}$ and the last one third has coefficient of friction μ.

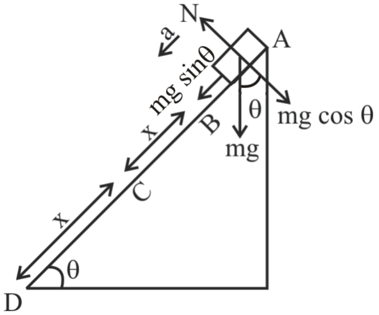
If the body comes to rest at the bottom of the plane then the value of μ is

(a) $\frac{\tan\theta}{2}$ (b) $\frac{3\tan\theta}{2}$

(c) tanθ (d) 2 tanθ

AP EAMCET (22.04.2019) Shift-II

Ans. (d) :



Let mass of body = m

AB = BC = CD = x

Plane coefficient of friction,

$$\mu_{AB} = 0, \mu_{BC} = \frac{\mu}{2}, \mu_{CD} = \mu$$

For inclined plane AB,

Friction force $(f_{AB}) = \mu N = 0 \times N = 0$

F_{net} equation,

$$mg\sin\theta - 0 = ma_{AB}$$

$$a_{AB} = g\sin\theta$$

Applying third equation of motion,

$$v^2 = u^2 + 2as$$

$$v_{AB}^2 = 2\times g\sin\theta\times x = 2gx\sin\theta$$

For inclined plane BC,

Friction force $(f_{BC}) = (\mu/2)mg\cos\theta$

So, net force equation–

$$mg\sin\theta - (\mu/2)mg\cos\theta = ma_{BC}$$

$$a_{BC} = g\sin\theta - \frac{\mu}{2}g\cos\theta$$

Applying third equation of motion,

$$v_{BC}^2 = u_{BC}^2 + 2a_{BC}x \qquad [\because u_{BC} = v_{AB}]$$

$$v_{BC}^2 = 2gx\sin\theta + 2\left(g\sin\theta - \frac{\mu}{2}g\cos\theta\right)x$$

$$v_{BC}^2 = 4gx\sin\theta - \mu gx\cos\theta$$

For CD,

Friction force $(f_{CD}) = \mu mg\cos\theta$

So, net force equation,

$$mg\sin\theta - \mu mg\cos\theta = ma_{CD}$$

$$a_{CD} = g\sin\theta - \mu g\cos\theta$$

Applying third equation of motion,

$$v_{CD}^2 = u_{CD}^2 + 2a_{CD}x = u_{BC}^2 + 2a_{CD}x$$

$$(\because u_{CD} = v_{BC})$$

$$0 = 6gx\sin\theta - 3\mu gx\cos\theta$$

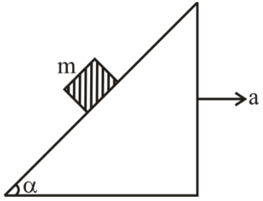
$$6gx\sin\theta = 3\mu gx\cos\theta$$

$$\mu = \frac{6gx\sin\theta}{3gx\cos\theta}$$

$$\mu = 2\tan\theta$$

549. A block of mass m is lying on a rough inclined plane having an inclination $\alpha = \tan^{-1}\left(\frac{1}{5}\right)$. The inclined plane is moving horizontal by with a constant acceleration of a = 2 ms^{-2} as shown in the figure. The minimum value of coefficient of friction, so that the block remains stationary with respect to the inclined plane is

(Take, g = 10 ms^{-2})



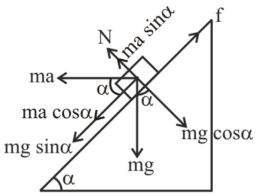
(a) $\frac{2}{9}$ (b) $\frac{5}{12}$

(c) $\frac{1}{5}$ (d) $\frac{2}{5}$

AP EAMCET (21.04.2019) Shift-I

Ans. (b) : Given, $\alpha = \tan^{-1}(1/5) \Rightarrow \tan\alpha = 1/5$

Acceleration (a) = 2m/sec^2



Resolving the forces

Perpendicular to the plane:

$$N + ma\sin\alpha = mg\cos\alpha$$

$$N = mg\cos\alpha - ma\sin\alpha \qquad .....(i)$$

Along to the plane:

$$mg\sin\alpha + ma\cos\alpha = f \qquad ......(ii)$$

We know,

$$\because \quad f = \mu N$$

$$\therefore \quad \mu = \frac{f}{N} \qquad ..... (iii)$$

Putting the value f and N from equation (i) and (ii) respectively in equation (iii), we get –

$$\mu = \frac{mg\sin\alpha + ma\cos\alpha}{mg\cos\alpha - ma\sin\alpha}$$

@apna_pdf

$$\mu = \frac{g\tan\alpha + a}{g - a\tan\alpha} \quad \text{(Dividing by m cos}\alpha)$$

Substituting $\tan\alpha = \frac{1}{5}$ and $a = 2\ m/s^2$

$$\mu = \frac{5}{12}$$

550. The force required to move a body up a rough inclined plane is double the force required to prevent the body from sliding down the plane. If the angle of inclination of the plane is 60°, then the coefficient of friction is

(a) $\frac{1}{3}$ (b) $\frac{1}{\sqrt{2}}$

(c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{2}$

AP EAMCET (20.04.2019) Shift-II

Ans. (c) : Given, angle of inclination θ = 60°

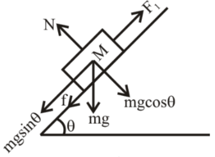


Fig.1
Body moving up

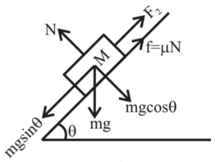


Fig.2
Body moving down

Resolving the forces perpendicular to the plane,

N = mgcosθ (from both the figure)

and f = μN

Then, f = μmgcosθ .....(i)

Resolving the forces parallel to the plane,

From figure-1,

$F_1 = mg\sin\theta + f$

$F_1 = mg\sin\theta + \mu mg\cos\theta$ .....(ii)

[From equation (i)]

From figure-2,

$F_2 = mg\sin\theta - f$

$F_2 = mg\sin\theta - \mu mg\cos\theta$ .....(iii)

[From equation (i)]

According to question,

$F_1 = 2F_2$

Then, $mg\sin\theta + \mu mg\cos\theta = 2[mg\sin\theta - \mu mg\cos\theta]$

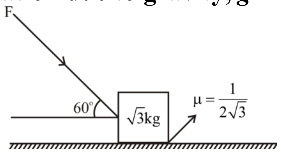
$3\mu mg\cos\theta = mg\sin\theta$

$3\mu\cos 60° = \sin 60°$ (θ = 60°)

$\tan 60° = 3\mu$

$$\mu = \frac{\sqrt{3}}{3} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{1}{\sqrt{3}}$$

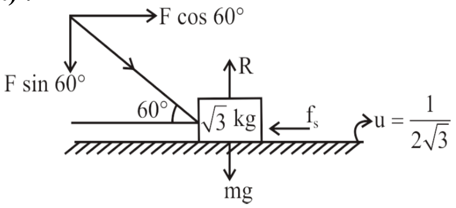
551. The maximum value of the applied force F such that the block as shown in the arrangement does not move is
(Acceleration due to gravity, $g = 10\ ms^{-2}$)



(a) 20 N (b) 15 N
(c) 25 N (d) 10 N

AP EAMCET (20.04.2019) Shift-1

Ans. (a) :



Given, $\mu = \frac{1}{2\sqrt{3}}$, $m = \sqrt{3}$ kg

From the figure, $\sum F_y = 0$

R = F sin 60° + mg

and, Friction force $f_s = \mu R$

$f_s = \mu R$

$f_s = \mu$ (F sin 60° + mg)

Block does not move

So,

F cos 60° = μ (Fsin60° + mg)

$$F \times \frac{1}{2} = \frac{1}{2\sqrt{3}}\left(F \times \frac{\sqrt{3}}{2} + \sqrt{3} \times 10\right)$$

$$\frac{F}{2} - \frac{F}{4} = 5$$

$$\frac{F}{4} = 5$$

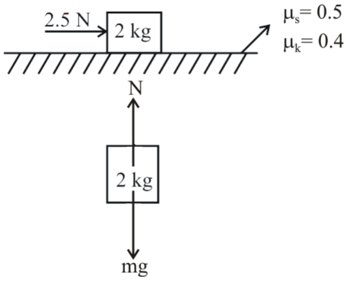
F = 20 N

552. A body of mass 2 kg is placed on a horizontal surface having kinetic friction 0.4 and static friction 0.5. If the force applied on the body is 2.5 N, then the frictional force acting on the body will be [$g = 10\ ms^{-2}$]

(a) 8 N (b) 10 N
(c) 20 N (d) 2.5 N

AIIMS-26.05.2018(M)

Ans. (d) :



From the figure,

N = m × g = 20 N

and limiting friction i.e. f_L is,

$f_L = \mu_s N = 0.5 \times 20 = 10N$

Hence, limiting friction is greater than applied force (i.e. applied force < f_L)

Hence, Friction force = 2.5 N

553. One end of a massless spring of spring constant 100 N m^{-1} and natural length 0.49 m is fixed and other end is connected to a body of mass 0.5 kg lying on a frictionless horizontal table. The spring remains horizontal. If the body is made to rotate at an angular velocity of 2 rad sec^{-1}, then the elongation of the spring will be

@apna_pdf

(a) 2 cm (b) 1 cm
(c) 0.5 cm (d) 0.25 cm

AMU-2018

Ans. (b) : Given,

$k = 100$ N/m, $l_0 = 0.5$ m, $m = 0.5$ kg

$\omega = 2$ rad/sec

Let elongation of the spring be

$F = kl$ which provides the necessary centripetal force $m\omega^2 r = m\omega^2(l + l_0)$

$$\therefore \quad kl = m\omega^2(l + l_0)$$

$$l = \frac{m\omega^2 l_o}{k - m\omega^2}$$

$$l = \frac{0.5\times 2^2 \times 0.5}{100 - 0.5\times 4} = \frac{1}{98}\text{ m}$$

$l = 1$ cm

554. The time taken by a block to slide down a smooth inclined plane of inclination 45° is t_1 and the time taken by the same block to slide down a rough inclined plane of coefficient of kinetic friction $\frac{2}{3}$ is t_2. If the length and angle of inclination of the rough plane are same as those of the smooth plane, then $\frac{t_1}{t_2}$ is

(a) $\frac{1}{\sqrt{3}}$ (b) $\frac{1}{\sqrt{2}}$

(c) $\frac{1}{2}$ (d) $\frac{2}{\sqrt{3}}$

AP EAMCET-25.04.2018, Shift-II

Ans. (a) : Given,

$$\theta = 45^o,\ \mu = \frac{2}{3}$$

Let s is the distance traveled by the block,

We know

Time taken by the block to slide down on smooth plane

$$t_1 = \sqrt{\frac{2s}{g\sin\theta}} \quad \text{.... (i)}$$

Time taken by the block to slide down on rough plane

$$t_2 = \sqrt{\frac{2s}{g\sin\theta - \mu g\cos\theta}} \quad \text{..... (ii)}$$

Dividing equation (ii) by equation (i) –

$$\frac{t_2}{t_1} = \sqrt{\frac{\sin\theta}{\sin\theta - \mu\cos\theta}}$$

$$\frac{t_2}{t_1} = \sqrt{\frac{\sin 45^o}{\sin 45^o - \frac{2}{3}\times\cos 45^o}}$$

$$\frac{t_2}{t_1} = \sqrt{\frac{\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}} - \frac{2}{3}\times\frac{1}{\sqrt{2}}}}$$

$$\frac{t_2}{t_1} = \sqrt{\frac{3}{1}}$$

$$\frac{t_1}{t_2} = \frac{1}{\sqrt{3}}$$

555. A block of 10 kg is sliding at an initial velocity of 5 m/s along the horizontal surface to the right. The surface has a coefficient of kinetic friction 0.3. The distance to which the block will slide before coming to rest is.

(Assume g = 10 m/s^2)

(a) 4.2m (b) 5.6m
(c) 3.8m (d) 4.8m

TS EAMCET (Medical)-02.05.2018, Shift-I

Ans. (a) : We know that,

$$\frac{1}{2}mv^2 = \mu mgd$$

$$v^2 = 2\mu\times g\times d$$

$$25 = 2\times 0.3\times 10\times d$$

$$d = 25/6 = 4.16\text{ m}$$

556. Which one of the following statements is incorrect?

(a) Frictional force opposes the relative motion
(b) Limiting value of static friction is directly proportional to normal reaction
(c) Rolling friction is smaller than sliding friction
(d) Coefficient of sliding friction has dimensions of length

NEET- 2018

Ans. (d) : Coefficient of sliding friction has no dimension

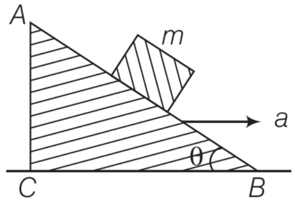
$$f = \mu_s N$$

$$\mu_s = \frac{f}{N}$$

Frictional force and normal force reaction both are have same unit Newton

So, that μ_s is dimensionless.

557. A block of mass m is placed on a smooth inclined wedge ABC of inclination θ as shown in the figure. The wedge is given an acceleration a towards the right. The relation between a and θ for the block to remain stationary on the wedge is



(a) $a = g\cos\theta$

(b) $a = \frac{g}{\sin\theta}$

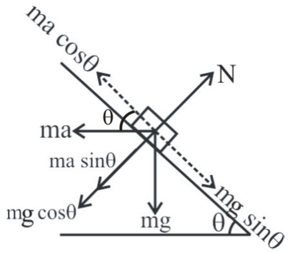
(c) $a = \frac{g}{\text{cosec}\,\theta}$

(d) $a = g\tan\theta$

NEET- 2018

@apna_pdf

Ans. (d) :



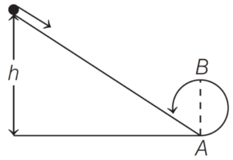
From free body diagram-

$$ma\cos\theta = mg\sin\theta$$

$$a = g\frac{\sin\theta}{\cos\theta}$$

$$a = g\tan\theta$$

558. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter AB=D. The height h is equal to



(a) $\frac{7}{5}D$ (b) D

(c) $\frac{3}{2}D$ (d) $\frac{5}{4}D$

NEET- 2018

Ans. (d) : Here, the total energy will be preserved therefore,

Total mechanical energy at A = total mechanical energy at B

$$mgh = \frac{1}{2}mv_B^2 + mg\,D \text{ .... (i)}$$

The minimum speed required to complete rotation is –

$$\text{Centripetal force} = \frac{m{v_B}^2}{r} = mg$$

$${v_B}^2 = rg$$

$$v_B = \sqrt{rg} = \sqrt{\frac{D}{2}\times g} \qquad \left[\because r = \frac{D}{2}\right]$$

$$v_B = \sqrt{\frac{Dg}{2}}$$

Putting the value of v_B in equation (i) –

$$mgh = \frac{1}{2}m\frac{Dg}{2} + mgD$$

$$mgh = mg\left(\frac{D}{4} + D\right)$$

$$h = \frac{D}{4} + D$$

$$h = \frac{5D}{4}$$

559. A car moves at a speed of 36 km/h on a level road. The coefficient of friction between the car tyres and the road is 0.8. The car negotiates a curve of radius R. if g =10ms^{-2} the car will skid (or slip) while negotiating the curve, if the value of R is

(a) 20 m (b) 14 m

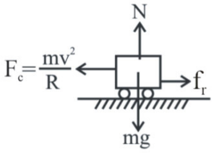
(c) 12 m (d) 50 m

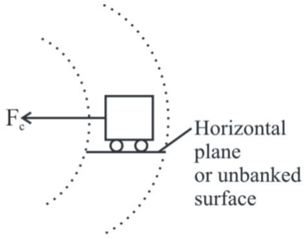
CG PET -2018

Ans. (c) : Given,

$$\mu_s = 0.8,\ g = 10 m/s^2,\ R = ?$$

$$v = 36 \text{ km/h} = \frac{36\times5}{18} = 10 m/sec$$





Friction force is

$f_r = \mu_s N = \mu_s mg$

Condition of turning the car,

Centripetal force ≥ friction force

$$F_c = f_r$$

$$\frac{mv^2}{R} = \mu_s mg.$$

$$v^2 = \mu_s gR$$

$$v = \sqrt{\mu_s g.R}$$

$$10 = \sqrt{0.8\times10\times R}$$

Squaring both side-

$$100 = 8 \times R \Rightarrow R = 12.5 \text{ m} \approx 12 \text{ m}$$

560. A cyclist comes to a skidding stop in 10 m. During this process, the force on the cycle due to the road is 200 N and is directly opposed to the motion. How much work does the road do on the cycle?

(a) 2000 J (b) –2000 J

(c) 20 J (d) – 20 J

J&K-CET-2018

Ans. (b) : Given,

Force on the cycle due to the road (f) = 200N

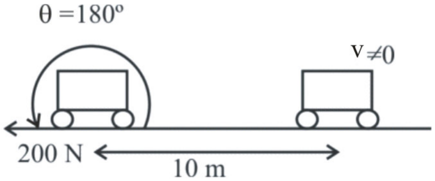
Travelled distance (s) = 10 m.

The work done on the cycle by the road = work done by the frictional force exerted by the road on the surface.

$$\therefore \qquad W = \vec{f}.\vec{s} = f.s.\cos\theta$$

$$= 200 \times 10 \times \cos 180^\circ$$

$$= -2000 \text{ Joule}$$



@apna_pdf

561. A block rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10N, the mass of the block is (Take $g = 10\ ms^{-2}$)

(a) 1 kg (b) 2 kg
(c) 3 kg (d) 4 kg

Karnataka CET-2018

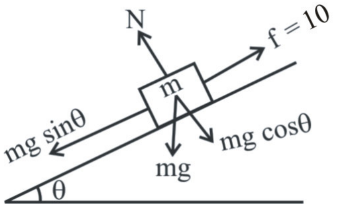
Ans. (b) : Given, block rest on rough surface inclined at 30º

Angle (θ) = 30º

Static friction (μ) = 0.8

Friction force (f) = 10N, $g = 10 m/s^2$

Suppose that mass of block is m



Balancing the force along the surface of the inclined plane we get,

$$f = mg\ \sin\theta$$
$$10 = m \times 10 \times \sin 30^\circ$$
$$m = \frac{10}{10 \times \sin 30^\circ} = \frac{10}{10 \times \frac{1}{2}}$$
$$m = \frac{10}{5}$$
$$m = 2kg$$

Hence, mass of block is 2 kg.

562. A boy of mass 50kg is climbing a vertical pole at a constant speed. If coefficient of friction between his palms and the pole is 0.75. The normal reaction between him and the pole is (take, $g = 10\ m/s^2$)

(a) 700 N (b) 625.67 N
(c) 550 N (d) 666.67 N

BCECE-2018

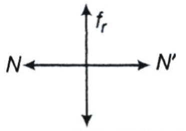
Ans. (d) : Given, m = 50 kg, μ = 0.75

Let the normal reaction is N.

Since, the boy is climbing with constant speed.

$\therefore \quad F_{net} = 0$ (on the boy)

Free body diagram



w = mg = 50×10 = 500 N

According to question –

$mg = f$ (friction force)

$mg = \mu N$ ($\because f = \mu N$)

$$N = \frac{mg}{\mu} = \frac{50 \times 10}{0.75} = 666.67N$$

563. A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2. The weight of the block is

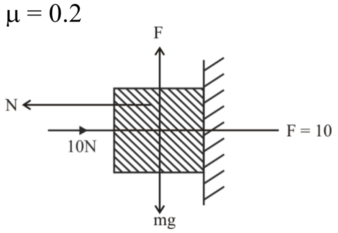
(a) 20 N (b) 50 N
(c) 100 N (d) 2 N

AIIMS-27.05.2018(M)

Ans. (d) : Given,

N = F = 10

μ = 0.2



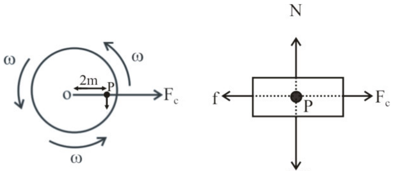
Now, $f = \mu.N = (0.2) \times 10 = 2$ N

564. A child is on a merry-go-round, standing at a distance of 2 m from the centre. The coefficient of static friction between the child and the surface of merry-go-round is 0.8. At what maximum angular velocity can the merry-go-round be rotated before the child slips? (Take, $g = 10\ m/s^2$)

(a) 0.5 rad/s (b) 1 rad/s
(c) 2 rad/s (d) 4 rad/s

TS-EAMCET-07.05.2018, Shift-1

Ans. (c) :



Given, μ = 0.8, r = 2m

Centripetal force $F_c = \frac{mv^2}{r} = mr\omega^2$

Friction force –

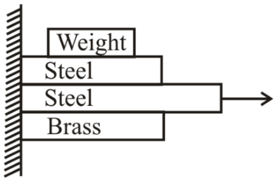
$$f = N\mu = \mu mg$$

At critical speed, maximum static friction must be equal to centrifugal force on child.

$$\mu N = mr\omega^2$$
$$0.8 \times m \times 10 = m.(2).\omega^2$$
$$8 = 2\omega^2$$
$$\omega^2 = \frac{8}{2}$$
$$\omega^2 = 4$$
$$\omega = \sqrt{4} = 2 \quad rad/s$$

565. A movable steel plate is placed between fixed steel and brass plates and the stack of plates is subjected to a weight of 100 N as shown in the figure. The coefficient of kinetic friction for steel on steel is 0.57 and for steel on brass is 0.44. Assuming that the entire weight comes into the stack and that the weight of the plates is negligible in comparison to the applied weight, the force required to move the middle plate (in N) is

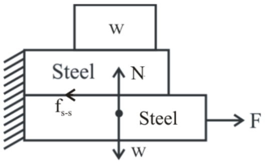
@apna_pdf



(a) 13 (b) 101
(c) 440 (d) 570

TS-EAMCET-04.05.2018, Shift-2

Ans. (b) :

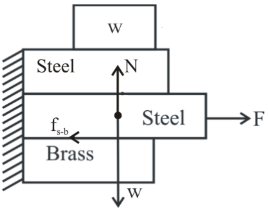


Given,

w = 100 N, N = 100 N

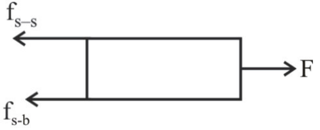
Friction force between steel–

$f_{s-s} = \mu_s \times N = 0.57 \times 100 = 57N$



Friction force between steel and brass –

$f_{s-b} = \mu_{s.\,b} \times N = 0.44 \times 100 = 44N.$

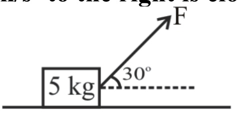


$F \ge f_{s-s} + f_{s-b}$

$F \ge 57 + 44 \Rightarrow F \ge 101$ N

F = 101 N.

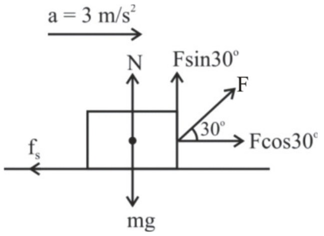
566. A block of mass 5 kg is pulled by a force F as shown in the figure. If the coefficient of friction is 0.1, then the force needed to accelerate the block to 3m/s^2 to the right is close to



(a) 12 N (b) 22N
(c) 32N (d) 42N

TS-EAMCET-05.05.2018, Shift-2

Ans. (b) : Given, m = 5kg, $\mu = 0.1$, a = 3 m/s^2



In vertical direction,

$N = mg - F\sin30^o$

Net force on block in horizontal direction,

$ma = F\cos30^o - f_s$

$ma = F\cos30^o - \mu N$

$= F\cos30^o - \mu(mg - F\sin30^o)$

$$5 \times 3 = F \times \frac{\sqrt{3}}{2} - 0.1\left(5 \times 10 - F \times \frac{1}{2}\right)$$

$$15 = \frac{\sqrt{3}\,F}{2} - 5 + \frac{0.1F}{2}$$

$$30 = \sqrt{3}\,F - 10 + 0.1F$$

$$1.8\,F = 40 \Rightarrow F = \frac{40}{1.8} = 22.22\text{ N} \approx 22\text{ N}$$

567. Sand is to be piled up on a horizontal ground in the form of a regular cone of a fixed base of radius R. coefficient of static friction between the sand layers is μ. Maximum volume of the sand can be piled up in the form of cone without slipping on the ground is

(a) $\frac{\mu R^3}{3\pi}$ (b) $\frac{\mu R^3}{3}$

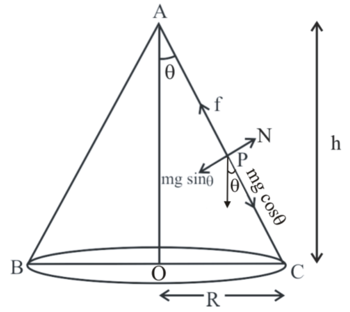
(c) $\frac{\pi R^3}{3\mu}$ (d) $\frac{\mu\pi R^3}{3}$

AP EAMCET (22.04.2018) Shift-1

Ans. (d) : Let, h = height of sand cone

θ = semi – vertical angle of cone

R = base radius



Consider a sand particle at point P

In equilibrium condition

N = mgsinθ

We know,

Friction force (f) = μN

f = μmg sinθ ….(i)

From figure

mg cosθ = f …(ii)

Putting the value of 'f ' in equation (ii)

mg cosθ = μ mg sinθ

$$\frac{\sin\theta}{\cos\theta} = \frac{1}{\mu}$$

$$\tan\theta = \frac{1}{\mu}$$

From triangle AOC

$$\tan\theta = \frac{OC}{AO} = \frac{R}{h}$$

$$\tan\theta = \frac{R}{h} = \frac{1}{\mu} \Rightarrow h = \mu R$$

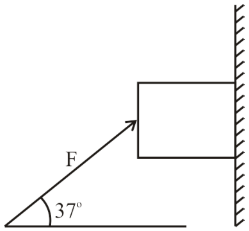
@apna_pdf

Therefore maximum volume of sand cone

$$V_{max} = \frac{1}{3}\pi r^2 h$$

Then, $V_{max} = \frac{1}{3}\pi R^2(\mu R) = \frac{\mu\pi R^3}{3}$

568. A block of mass 2 kg is being pushed against a wall by a force F = 90 N as shown in the figure. If the coefficient of friction is 0.25. Then the magnitude of acceleration of the block is (Take, $g = 10\ ms^{-2}$) $\left(\sin 37^o = \frac{3}{5}\right)$



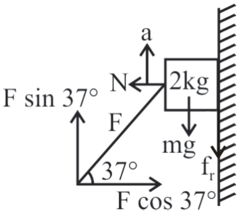
(a) 16 ms^{-2} (b) 8 ms^{-2}
(c) 38 ms^{-2} (d) 54 ms^{-2}

AP EAMCET (22.04.2018) Shift-1

Ans. (b) : Given, Coefficient of friction (μ)= 0.25

mass (m) = 2 kg, applied force (F) = 90N, $\sin 37° = \frac{3}{5}$

and $\cos 37° = \frac{4}{5}$



Block move upward

Resolving the forces along x and y direction –

Net horizontal force, $\Sigma F_x = 0$

$$N = F\cos(37^o)$$

$$N = 90\times\frac{4}{5} = 54\ N$$

Friction force $(f_r) = \mu N = 0.25 \times 90 \times\frac{4}{5}$ $\{N = F\cos 37^o\}$

$$f_r = 18N$$

Net vertical force, $\Sigma F_y = 0$

$$F\sin 37° - mg - f_r = ma$$

$$90\times\frac{3}{5} - 2\times 10 - 18 = 2a$$

$$54 - 38 = 2a$$

$$a = 8\ m/sec^2$$

569. If the coefficient of static friction between shoes of a runner and the track is 0.85, the greatest acceleration that can be generated by the runner is (here, g gravitational acceleration)

(a) 1.85 g (b) g
(c) 0.85 g (d) 0.15 g

UPSEE - 2018

Ans. (c) : Given,

$$\mu = 0.85$$

Friction force $(f) = \mu N = \mu mg$

So, $ma = \mu mg$

$$a = \mu g$$

∴ $a = 0.85g$

Hence, the greatest acceleration (a) that can be generated by the runner is 0.85g.

570. A body of mass m = 1kg is moving in a medium and experiences a fractions force F = –kv, where v is the speed of the body. The initial speed is $v_0 = 10\ ms^{-1}$ and after 10s, its energy becomes half of initial energy. Then, the value of k is

(a) $10\ \ln\sqrt{2}$ (b) $\ln\sqrt{2}$
(c) $\frac{\ln 2}{20}$ (d) 10 ln 2
(e) ln 2

Kerala CEE -2018

Ans. (c) : Given that,

Here, $m = 1kg,\ v_o = 10m/s,\ t = 10s,\ F = -kv$

According to question,

$$\frac{1}{2}mv^2 = \frac{1}{2}\times\frac{1}{2}mv_o^2$$

$$v^2 = \frac{v_o^2}{2} = \frac{10}{\sqrt{2}}$$

∵ $f = -kv$

$$ma = -kv$$

$$m\frac{dv}{dt} = -kv$$

$$\frac{dv}{v} = \frac{-k}{m}dt$$

Integrating both side,

$$\int_{10}^{10/\sqrt{2}}\frac{1}{v}dv = -\int_0^{10}kdt \qquad [\because\ m = 1kg]$$

$$(\ln v)_{10}^{10/\sqrt{2}} = -k(t)_0^{10}$$

$$\ln\left(\frac{10}{\sqrt{2}}\right) - \ln 10 = -k(10)$$

$$\ln 10 - \ln\left(\frac{10}{\sqrt{2}}\right) = 10k$$

$$\ln\left(\frac{10}{10/\sqrt{2}}\right) = 10K \Rightarrow \ln\sqrt{2} = 10K$$

$$K = \frac{\ln 2/2}{10} \Rightarrow K = \frac{\ln 2}{20}$$

571. Two charged particles of each of mass 3 g and charge 0.2 μC stay in (vacuum) equilibrium on a horizontal surface with a separation of 20 cm. the coefficient of friction is

$$\left[\frac{1}{4\pi\varepsilon_0} = 9\times 10^9\ Nm^2C^{-2}\right](g = 10ms^{-2})$$

@apna_pdf

(a) 0.20 (b) 0.18
(c) 0.25 (d) 0.30

AP EAMCET-24.04.2017, Shift-II

Ans. (d) : Given,

$q_1 = q_2 = 0.2\ \mu C = 0.2 \times 10^{-6}$ C

r = 20 cm = 0.2 m

m = 3g = 3×10^{-3} kg

μ = ?

We know that,

$$F = \mu R = \mu mg$$

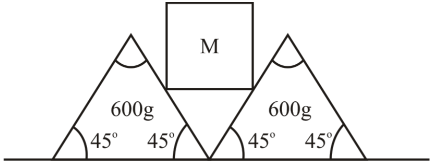
$$\frac{q_1 q_2}{4\pi\varepsilon_0 r^2} = \mu mg$$

$$\mu = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2 mg}$$

$$\mu = \frac{0.2\times10^{-6}\times0.2\times10^{-6}\times9\times10^9}{(0.2)^2\times3\times10^{-3}\times10}$$

$$\mu = 0.3$$

572. Two wedges each of mass 600 g are placed next to each other on a rough horizontal surface. The coefficient of static friction between the wedges and the surface is 0.4. A cube of mass 'M' is balanced on the wedges as shown in the figure. If there is no friction between the cube and wedges, the largest mass 'M' of the cube that can be balanced without motion of the wedges is____ kg.



(a) 0.8 (b) 0.6
(c) 0.3 (d) 1.2

AP EAMCET-25.04.2017, Shift-I

Ans. (a) : Given,

μ = 0.4

m = 600 gm = 0.6 kg

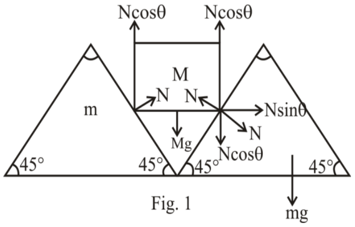


Fig. 1

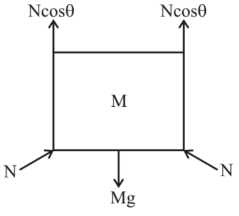


Fig.2

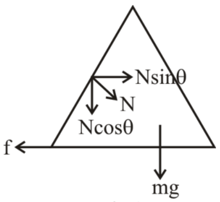


Fig.3

From figure (2)

$$2N\cos45° = mg$$

$$\sqrt{2}N = Mg$$

$$N = \frac{Mg}{\sqrt{2}}$$

$$f = \mu(N\cos\theta + mg)$$

$$f = \mu\left(\frac{Mg}{\sqrt{2}}\times\frac{1}{\sqrt{2}} + mg\right)$$

$$= \mu g\left(\frac{M}{2} + m\right) \quad \text{....(i)}$$

If wedge is balanced,

$$F = N\sin\theta = \frac{Mg}{\sqrt{2}}\sin45° = \frac{Mg}{2} \quad \text{.....(ii)}$$

From equation (i) & (ii),

$$\frac{\mu Mg}{2} + \mu mg = \frac{Mg}{2}$$

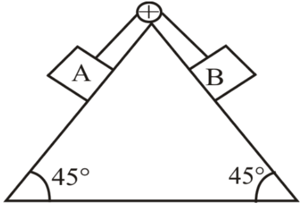
$$\mu mg = \frac{Mg}{2} - \frac{\mu Mg}{2}$$

$$M = \frac{2\mu m}{(1-\mu)}$$

$$M = \frac{2\times0.4\times0.6}{1-0.4}$$

$$M = 0.8$$

573. The arrangement shown in the figure, masses of blocks A and B are 'm' and '2m' respectively. The string is massless and inextensible. Pully is frictionless. The coefficients of static friction between A and the wedge surface is $\frac{2}{3}$ between B and the wedge surface is $\frac{1}{3}$. If the blocks A and B are relased from rest, acceleration of block A is

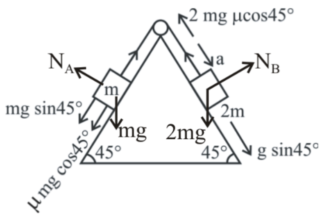


(a) $\frac{g}{2}$ (b) zero

(c) $\frac{g}{2\sqrt{2}}$ (d) $\frac{g}{\sqrt{2}}$

AP EAMCET-28.04.2017, Shift-II

Ans. (b) :



Total supporting force = 2mg sin45° – mg sin45°

$$= \frac{2mg}{\sqrt{2}} - \frac{mg}{\sqrt{2}} = \frac{mg}{\sqrt{2}}$$

@apna_pdf

∴ Maximum available friction force = $\mu_A N_A + \mu_B N_B$

$$= \frac{2}{3}\times\frac{mg}{\sqrt{2}}+\frac{1}{3}\times\frac{2mg}{\sqrt{2}}$$

$$=\frac{4mg}{3\sqrt{2}} \text{ which is } > \frac{mg}{\sqrt{2}}$$

Since the maximum apposing force is more, the mass system will not move i.e. acceleration, a = 0

574. Two cars are moving on a banked circular path of radius 8 m having angle of banking 45°. If the coefficients of static friction between the road and the tyres of the two cars are 0.5 and 0.4 respectively, then the ratio of maximum permissible speeds of the cars to avoid slipping is

(a) $\sqrt{7}:\sqrt{5}$ (b) $\sqrt{9}:\sqrt{7}$

(c) $\sqrt{11}:\sqrt{7}$ (d) $\sqrt{13}:\sqrt{11}$

AP EAMCET-26.04.2017, Shift-II

Ans. (b) : Given, two cars are moving on a banked circular path is,

Radius = 8 m

$\mu_1 = 0.5$, $\mu_2 = 0.4$

$\tan\theta = \tan 45^\circ = 1$

Use $g = 9.8 \text{ m/s}^2$

And static friction between road and the tyres

For first car $(\mu_s)_1 = 0.5$

For second car $(\mu_s)_2 = 0.4$

Maximum permissible speed of the first car to avoid slipping is,

$$v_1 = \sqrt{\frac{rg[\mu_1+\tan\theta]}{[1-\mu_1\tan\theta]}} \quad .....(i)$$

Maximum permissible speed of the second car to avoid slipping is,

$$v_2 = \sqrt{\frac{rg[\mu_2+\tan\theta]}{[1-\mu_2\tan\theta]}} \quad .....(ii)$$

$$\frac{v_1}{v_2} = \frac{\sqrt{\frac{\mu_1+\tan\theta}{1-\mu_1\tan\theta}}}{\sqrt{\frac{\mu_2+\tan\theta}{1-\mu_2\tan\theta}}}$$

$$\frac{v_1}{v_2} = \frac{\sqrt{\frac{0.5+1}{1-0.5\times1}}}{\sqrt{\frac{0.4+1}{1-0.4\times1}}}$$

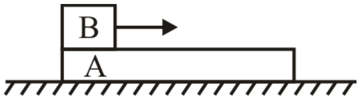
$$= \frac{\sqrt{1.5/0.5}}{\sqrt{1.4/0.6}}$$

$$= \frac{\sqrt{3}}{\sqrt{7/3}}$$

$$= \sqrt{\frac{9}{7}}$$

$$v_1 : v_2 = \sqrt{9}:\sqrt{7}$$

575. A long block A of mass M is at rest on a smooth horizontal surface. A small block B of mass M/2 is placed on A at one end and projected along A with some velocity v. The coefficient of friction between the block is μ. Then, the accelerations of blocks A and B before reaching a common velocity will be respectively



(a) $\frac{\mu g}{2}$ (towards right), $\frac{\mu g}{2}$ (towards left)

(b) μg (towards right), μg (towards left)

(c) $\frac{\mu g}{2}$ (towards right), μg(towards left)

(d) μg (towards right), $\frac{\mu g}{2}$ (towards left)

JIPMER-2017

Ans. (c) : Given, $m_A = m,\ m_B = \frac{m}{2}$

Friction force between A and B = $\mu m_B g = \mu\frac{m}{2}g$ ...(i)

$F_A = m_A a_A$

$= m a_A$ ....(ii)

Equating equation (i) and (ii), we get–

$$= \mu\frac{m}{2}g = ma_A$$

$$= \frac{\mu g}{2} = a_A \quad \text{(towards Right)}$$

For block B experience friction force toward left–

$F_B = \mu m_B g$

$m_B a_B = \mu m_B g$

$a_B = \mu g$ (towards Left)

576. Consider a car moving at a constant speed of 14m/s around a level circular bend of radius 45m. The minimum coefficient of static friction needed between the car tyres and the road so that the car goes around the bend without skidding is

(a) 0.44 (b) 1.0

(c) 4.4 (d) 0.1

TS EAMCET(Medical)-2017

Ans. (a) : Given,

Radius of circular bend (r) = 45 m

Speed of car (v) = 14 m/s

We know that,

$v^2 = \mu g r$

$$\mu = \frac{v^2}{gr}$$

$$\mu = \frac{(14)^2}{45\times9.8}$$

$\mu = 0.44$

@apna_pdf

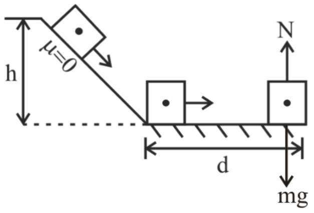
577. Consider a frictionless ramp on which a smooth object is made to slide down from an initial height 'h'. The distance 'd' necessary to stop the object on a flat track (of coefficient of friction 'μ'), kept at the ramp end is

(a) h/μ (b) μh

(c) $\mu^2 h$ (d) $h^2\mu$

TS EAMCET (Engg.)-2017

Ans. (a) :



From conservation of energy

Potential energy = friction force × distance

$mgh = f \times d$

$mgh = \mu N \times d$

$mgh = \mu mg \times d$

$d = h/\mu$

578. A wooden box lying at rest on an inclined surface of a wet wood is held at static equilibrium by a constant force $\vec{F}$ applied perpendicular to the incline. If the mass of the box is 1 kg the angle of inclination is 30° and the coefficient of static friction between the box and the inclined plane is 0.2, the minimum magnitude of $\vec{F}$ is (Use $g = 10 m/s^2$)

(a) 0N, as 30° is less than angle of repose

(b) ≥ 1 N

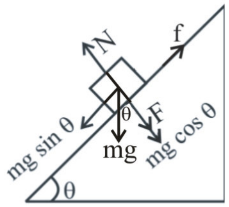
(c) ≥ 3.3 N

(d) ≥ 16.3 N

TS EAMCET (Engg.)-2017

Ans. (d) :

Given, $\theta = 30^o$, $\mu = 0.2$, $m = 1$ kg, $g = 10$ m/s^2



From F.B.D.

$N = F + mg\cos\theta$

And,

$f = mg\sin\theta$

$\mu N = mg\sin\theta$

$\mu(F + mg\cos\theta) = mg\sin\theta$

$$= \frac{mg}{\mu}[\sin\theta - \mu\cos\theta]$$

$$= \frac{1\times10}{0.2}[\sin 30^o - 0.2\cos 30^o]$$

$$= \frac{10}{0.2}\left[\frac{1}{2} - 0.2\left(\frac{\sqrt{3}}{2}\right)\right]$$

$= 50\,(0.5 - 0.1732)$

$\vec{F}_{min} = 16.34$ N

Hence, minimum magnitude of force must be ≥ 16.3 N

579. A bullet of mass 4.2×10^{-2} kg, moving at a speed of 300 ms^{-1}, gets stuck into a block with a mass 9 times that of the bullet. If the block is free to move without any kind of friction, the heat generated in the process will be

(a) 45 cal (b) 405 cal

(c) 450 cal (d) 1701 cal

WB JEE 2017

Ans. (b) : Given,

Velocity of bullet = 300 m/s

Let mass of bullet = m

So, mass of block = 9m

When bullet gets struck to block,

then both will move with same velocity (V)

$mv = (m + 9m)V$

$$V = \frac{v}{10}$$

Heat generated = Loss in kinetic energy of bullet

$$\text{Heat generated} = \frac{1}{2}mv^2 - \frac{1}{2}(10m)V^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}(10m)\left(\frac{v}{10}\right)^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}\times\frac{mv^2}{10} = \frac{9}{20}mv^2$$

By putting the value of $m = 4.2 \times 10^{-2}$ kg and

$v = 300$ m/s^2

$= 1701$ J

Now,

$$\text{Heat generated} = \frac{1701}{4.2} = 405\,\text{cal}$$

Hence, Heat generated in the process will be 405 cal.

580. A conveyer belt moves at a steady rate of 2ms^{-1} sand is poured on the belt at 5kg-s^{-1}. Find the constant force required to maintain the speed of the belt.

(a) 3 N (b) 7 N

(c) 2.5 N (d) 10 N

J&K-CET-2017

Ans. (d) : Given,

Velocity of conveyer belt (v) = 2m/sec

Sand is poured (m) = 5 kg/sec

The constant force, to maintain the speed of the belt

$F = mv$

$F = 5$kg/sec × 2m/sec

$$F = 10\frac{kgm}{sec^2}$$

$F = 10$ N

∴ Constant force =10N

@apna_pdf

581. Which of the following is a self adjusting force?

(a) Static friction
(b) Limiting friction
(c) Dynamic friction
(d) Sliding friction

VITEEE-2017

Ans. (a) : A self adjusting force can be defined as a force which can change its magnitude as required in the system.
Static-friction is a self-adjusting force.

582. The retarding acceleration of 7.35 ms^{-2} due to frictional force stops the car of mass 400 kg travelling on a road. The coefficient of friction between the tyre of the car and the road is

(a) 0.55　　(b) 0.75
(c) 0.70　　(d) 0.65

AIIMS-2017

Ans. (b) : Given, $a = 7.35\ ms^{-2}$, m = 400 kg
Newton's 2nd law-

$$F_{net} = ma$$
$$\mu mg = ma$$
$$\mu = \frac{ma}{mg} = \frac{a}{g}$$
$$\mu = \frac{7.35}{9.8} = 0.75$$

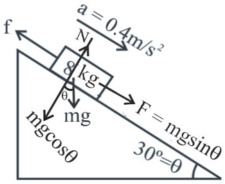
583. A wooden box of mass 8 kg slides down an inclined plane of inclination 30° to the horizontal with a constant acceleration of 0.4 $m\,s^{-2}$. What is the force of friction between the box and inclined plane? $\left[g = 10\ m\,s^{-2}\right]$

(a) 36.8 N　　(b) 76.8 N
(c) 65.6 N　　(d) 97.8 N

COMEDK 2017

Ans. (a) : Given that,

m = 8 kg
$\theta = 30°$
$a = 0.4\ m/s^2$

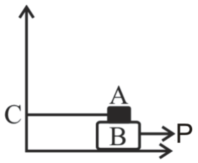


We know that,

$$F = ma$$
$$mg \sin 30° - f = ma$$
$$f = mg \sin 30° - ma$$
$$f = 8 \times 10 \times \frac{1}{2} - 8 \times 0.4$$
$$f = 40 - 3.2$$
$$f = 36.8\ N$$

∴ Frictional force = 36.8N

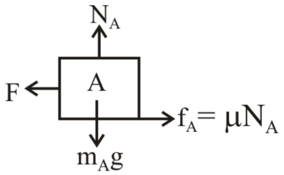
584. Block A of weight 100 kg rests on a block B and is tied with horizontal string to the wall at C. Block B is of 200 kg. The coefficient of friction between A and B is 0.25 and that between B and surface is $\frac{1}{3}$. The horizontal force F necessary to move the block B should be ($g = 10\ m/s^2$)



(a) 1050 N　　(b) 1450 N
(c) 1050 N　　(d) 1250 N

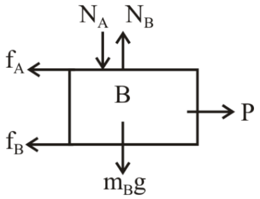
BITSAT-2017

Ans. (d) : Given, $m_A = 100$ kg, $m_B = 200$ kg, $\mu_1 = 0.25$
$\mu_2 = 1/3$



From Block A
Resolving the forces along x and y direction

$$\Sigma F_y = 0$$
$$N_A = m_A g$$
$$N_A = 100 \times 10$$
$$N_A = 1000\ N \quad \ldots(i)$$
$$\Sigma F_x = 0$$
$$F = \mu N_A$$
$$F = 0.25 \times 1000$$
$$F = 250\ N \quad \ldots(ii)$$



From Block B
Resolving the forces along x and y direction
$\Sigma F_x = 0$

$$f_A + f_B = P \quad \ldots(iii)$$

and
$\Sigma F_y = 0$

$$N_B = m_B g + N_A \quad \ldots(iv)$$
$$N_B = 200 \times 10 + 1000$$
$$N_B = 3000N$$

From equation (iii)

$$\mu_A N_A + \mu_B N_B = P$$
$$P = \frac{1}{4} \times 1000 + \frac{1}{3} \times 3000$$
$$P = 250 + 1000$$
$$P = 1250\ N$$

@apna_pdf

585. **A curved road of diameter 1.8 km is banked, so that no friction is required at a speed to 30m/s. What is the banking angle?**

(a) 6º (b) 16º

(c) 26º (d) 0.6º

JCECE-2017

Ans. (a) : Given,

d = 1.8 km

$r = \frac{1.8}{2} = 0.9 \text{ km} = 900 \text{ m}$

v = 30 m/s

We know that,

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan\theta = \frac{(30)^2}{900\times10} = \frac{1}{10}$$

$$\theta = \tan^{-1}\left[\frac{1}{10}\right]$$

$$\theta = \tan^{-1}(0.1) = 5.71^o \approx 6^o$$

586. **A time varying horizontal force (in Newton) F = 8$|\sin(4\pi t)|$ is acting on a stationary block of mass 2kg as shown. Friction coefficient between the block and ground is μ = 0.5 and g = 10m/s^2. Then resulting motion of the block will be**

(a) It will oscillate

(b) It remains stationary

(c) It moves towards left

(d) It moves towards right

UPSEE - 2017

Ans. (b) : Given,

Mass of Block (m) = 2kg

Varying horizontal force $= 8|\sin(4\pi t)|$ N

Friction coefficient between (Block and Ground), $\mu = 0.5$

$$g = 10 \text{m/s}^2$$

We know,

$$f_{max} = \mu mg$$

$$= 0.5\times2\times10 = 10\text{N} \quad .....(i)$$

Maximum applied force

$$F_{\text{applied max}} = 8\times1 = 8\text{N} \quad .....(ii)$$

$$[\because \sin\theta_{max} = 1]$$

From equation (i) & (ii) we get –

$$f_{max} > F_{\text{applied max}}$$

Hence, Block will remain stationary.

587. **An engine of power 58.8 kW pulls a train of mass 2 × 10^5 kg with a velocity of 36 kmh^{-1}. The coefficient of friction is**

(a) 0.3 (b) 0.03

(c) 0.003 (d) 0.0003

(e) 0.04

Kerala CEE - 2016

Ans. (c) : Given that,

Power of engine $(P) = 58.8\times10^3$ W

Mass of Train $(m) = 2\times10^5$ kg

Velocity of Train $(v) = 36\text{km/h} = \frac{36\times5}{18} = 10\text{m/s}$

We know that,

Power (P) = F.v

$$\therefore \quad F = \frac{P}{v} = \frac{58.8\times10^3}{10} = 5880\text{N}$$

Let, the coefficient of friction,

$$\therefore \quad F = f_S = \mu mg$$

$$\mu = \frac{F}{mg} = \frac{5880}{2\times10^5\times10} = 0.00294 \approx 0.003$$

588. **A mass of 1 kg is just able to slide down the slope of an inclined rough surface when the angle of inclination is 60º. The minimum force necessary to pull the mass up the inclined plane (g = 10 ms^{-2}) is**

(a) 14.14 N (b) 17.32 N

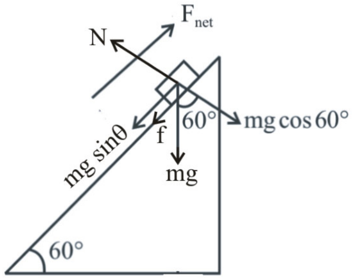
(c) 10 N (d) 16.66 N

(e) 0.866 N

Kerala CEE - 2009

Ans. (b) : Given, θ = 60°, m = 1 kg, g = 10 m/s

$$\mu = \tan\theta = \tan60^o = \sqrt{3}$$



$$F_{net} = mg\sin 60° + f = mg\sin60^o + \mu N$$

$$= mg\sin60^o + \mu mg\cos60^o$$

$$F_{net} = mg(\sin60° + \mu\cos60°)$$

$$= 1\times10\left(\frac{\sqrt{3}}{2} + \sqrt{3}\times\frac{1}{2}\right)$$

$$= 10\times\sqrt{3}$$

$$= 10\times1.732 = 17.32\text{N}$$

589. **A car of mass 1000kg moves on a circular track of radius 20m. If the coefficient of friction is 0.64, then the maximum velocity with which the car can move is :**

(a) 15 m/s (b) 11.2 m/s

(c) 20 m/s (d) 18 m/s

(e) 22.4 m/s

Kerala CEE 2006

@apna_pdf

Ans. (b) : Given that,

Coefficient of friction $(\mu) = 0.64$

Radius of circular track $(r) = 20\text{m}$

Gravitational acceleration of the body $(g) = 10\text{m/s}^2$

Mass = 1000 kg

According the relation between centripetal force and frictional force

Frictional force = Centripetal force

$$\mu mg = \frac{mv^2}{r}$$

$$v^2 = \mu rg$$

$$v = \sqrt{\mu rg} \qquad .....(i)$$

From eq^n (i), the maximum velocity

$$v = \sqrt{0.64 \times 20 \times 10}$$

$$= \sqrt{2 \times 64} \quad = 8\sqrt{2}$$

$$= 8 \times 1.414 = 11.31\text{m/s} \approx 11.2\text{m/s}$$

590. A uniform metal chain is placed on a rough table such that one end of it hangs down over the edge of the table. When one-third of its length hangs over the edge, the chain starts sliding. Then, the coefficient of static friction is:

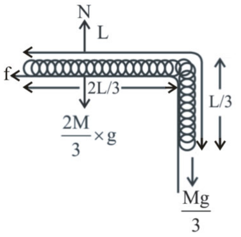
(a) $\frac{3}{4}$ (b) $\frac{1}{4}$

(c) $\frac{2}{3}$ (d) $\frac{1}{3}$

(e) $\frac{1}{2}$

Kerala CEE 2005

Ans. (e) :



Let the mass of the chain be M. When $\frac{1}{3}$ of the chain hangs down the edges magnitude of the force on the chain in the downward direction is equal to the weight of $\frac{1}{3}$ of the chain i.e. Mg/3

Then, the mass of chain portion of the chain lying the table is 2M/3. The magnitude of normal reaction is 2Mg/3.

∴ Maximum force of friction on the chain = μ_s (2Mg/3).

When the chain just starts sliding

Force on the chain hangs down the edges = Force on the chain lying the table

∴ $\quad Mg/3 = \mu_s\,(2Mg/3)$

$$\mu_s = \frac{1}{2}$$

591. An ice cart of mass 60 kg rests on a horizontal snow patch with coefficient of static friction $\frac{1}{3}$. Assuming that there is no vertical acceleration, find the magnitude of the maximum horizontal force required to move the ice cart.

($g = 9.8\ \text{ms}^{-2}$)

(a) 100 N (b) 110 N

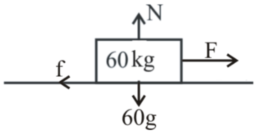
(c) 209 N (d) 206 N

(e) 196 N

Kerala CEE 2004

Ans. (e) : Given that, mass of ice cart (m) = 60 kg

Coefficient friction $(\mu) = 1/3$, $\quad g = 9.8\text{m/s}^2$



Force applies against friction,

$$F = \mu N = \mu mg$$

$$= \frac{1}{3} \times 60 \times 9.8 = 196\text{N}$$

∴ $\quad$ Maximum horizontal force = 196N

592. If a body have kinetic energy T, moving on a rough horizontal surface stops at distance y. The frictional force exerted on the body is

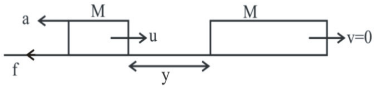
(a) $\frac{T}{\sqrt{y}}$ (b) $\frac{\sqrt{T}}{y}$

(c) yT (d) $\frac{T}{y}$

UPSEE - 2015

J&K CET-2009

Ans. (d) :



Mass = M

Velocity = u

Distance = y

According to the 3rd equation of motion,

$$v^2 = u^2 + 2as$$

$$0 = u^2 + 2(-a)y$$

[Retardation due to friction (a) = μg]

$$u^2 = 2ay = 2\mu gy \qquad ....(i)$$

Initial kinetic energy (T) = $\frac{1}{2}mu^2$

$$u^2 = \frac{2T}{m} \qquad ....(ii)$$

From equation (i) and (ii), we get-

$$\frac{2T}{m} = 2\mu g\,y$$

$$T = m\mu g\,y = fy \quad [\because f = \mu mg]$$

$$f = \frac{T}{y}$$

@apna_pdf

593. If a ladder weighing 250 N is placed against a smooth vertical wall having coefficient of friction between it and floor is 0.3, then what is the maximum force of friction available at the point of contact between the ladder and the floor?

(a) 75 N (b) 50 N
(c) 35 N (d) 25 N

UPSEE - 2014

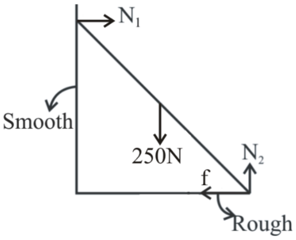
Ans. (a) : Given that,

Weight = 250N

$\mu = 0.3$

$N_2 = 250N$

Vertical direction,



Let the maximum frictional force,

$\therefore \quad f = \mu N_2$

$f = 0.3 \times 250$

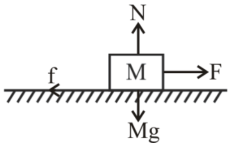
$f = 75N$

594. A body of mass M is kept on a rough horizontal surface (friction coefficient μ). A person is trying to pull the body by applying a horizontal force but the body is not moving. The force by the horizontal surface on the surface of the body is F, where

(a) $F = Mg$
(b) $F = \mu mgF$
(c) $Mg \le f \le Mg\sqrt{1+\mu^2}$
(d) $Mg \ge f \ge Mg\sqrt{1+\mu^2}$

UPSEE - 2013

Ans. (c) :



In vertical component, $N = Mg$

Friction force $(f_s) = \mu N$

$f_s = \mu Mg \quad [\because N = Mg]$

Maximum force by surface when friction work

$$f = \sqrt{f_s^2 + F^2}$$

$$= \sqrt{(\mu Mg)^2 + (Mg)^2}$$

$$f = Mg\sqrt{\mu^2 + 1}$$

$$f = Mg\sqrt{\mu^2 + 1}$$

$$Mg \le f \le Mg\sqrt{1+\mu^2}$$

595. The coefficient of limiting friction μ is defined as

(a) $\mu = \frac{R}{F}$ (b) $\mu = \sqrt{\frac{F}{R}}$
(c) $\mu = \frac{F}{R}$ (d) $\mu = \sqrt{\frac{R}{F}}$

UPSEE - 2008

Ans. (c) :

The limiting friction is directly proportional to the normal reaction

If, F = limiting friction

R = Normal Reaction

Then, $\mu = \frac{F}{R}$

$\mu =$ Coefficient of friction

(coeff. doesn't have any unit)

596. A block moving on a surface with velocity 20 m/s comes to rest because of surface friction over a distance of 40m. Taking ($g = 10\ m/s^2$), the coefficient of dynamic friction is:

(a) 0.5 (b) 0.3
(c) 0.2 (d) 0.1

UPSEE - 2005

Ans. (a) : Given, v = 0, u = 20 m/s, s = 40 m

Now, $v^2 = u^2 - 2as$

$(0)^2 = u^2 - 2as$

$u^2 = 2as$

$$a = \frac{u^2}{2s} = \frac{20 \times 20}{2 \times 40} = \frac{10}{2} = 5m/s^2$$

Now, applying the Newton's second law

Kinetic friction = ma

$\mu_k mg = ma$

$\mu_k = \frac{a}{g}$

$\mu_k = \frac{5}{10}$

$\mu_k = 0.5$

597. A block of mass M= 10kg rests on a horizontal table. The coefficient of friction between the block and table is 0.05, when hit by a bullet of mass 50g moving with speed v, that gets embedded in it, the block moves and comes to stop after moving a distance of 2m on the table. If a freely falling object were to acquire speed $\frac{v}{10}$ after being dropped from height H, then neglecting energy losses and taking $g = 10\ ms^{-2}$, the value of H is close to

(a) 0.02 km (b) 0.03km
(c) 0.04 km (d) 0.05km

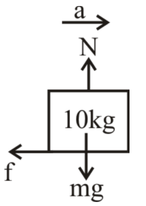
CG PET -2016

@apna_pdf

Ans. (c) : Given that, mass of block (M) = 10 kg, mass of bullet (m) = 50 g = 5×10^{-2} kg, bullet speed = v

Distance covered by the block (S) = 2m, $\mu = 0.05$

FBD of the Block of Mass



Resolving the forces along x and y-axis–

$\Sigma F_y = 0$

$$N = mg$$
$$N = 10 \times 10 = 100N$$

and $\Sigma F_x = 0$

$$f = ma$$
$$a = \frac{\mu N}{m} \qquad (f = \mu N)$$
$$= \frac{0.05 \times 100}{10}$$
$$a = 0.5 \text{ m/s}^2$$

Because block moves 2 m distance, we get –

$$v_{block}^2 = u_{block}^2 + 2as$$
$$v_{block}^2 = 0 + 2 \times 0.5 \times 2$$
$$v_{block} = \sqrt{2} \text{ m/s}$$

Apply law of conservation of momentum

$$Mv_{block} = mv$$
$$10 \times \sqrt{2} = 0.05v$$
$$v = \frac{10\sqrt{2}}{0.05} \text{m/s}$$
$$v = 2\sqrt{2} \times 10^2 \text{ m/s} \text{ ....(i)}$$

If objects is free falling from height H.

$$v^2 = u^2 + 2gH \qquad \left[\text{given } v = v/10\right]$$
$$\left(\frac{v}{10}\right)^2 = 0 + 2 \times 10 \times H$$

Putting the value of v from equation (i), we get –

$$\frac{\left(2\sqrt{2} \times 10^2\right)^2}{100} = 20H$$
$$H = 40 \text{ m}$$
$$H = \frac{40}{1000} \text{km}$$
$$H = 0.04 \text{km}$$

598. A block of mass M is pulled by a force F in the direction at an angle θ from the horizontal surface. Friction coefficient between block and surface is μ. The value of force F is

(a) μMg

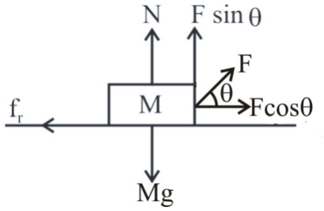
(b) $\dfrac{\mu Mg}{1 + \mu \sin\theta}$

(c) $\dfrac{\mu Mg}{\cos\theta + \mu \sin\theta}$

(d) None of the above

CG PET- 2013

Ans. (c) : Given that, mass of block = M



From figure,

$\Sigma F_y = 0$

$$N + F\sin\theta = Mg$$
$$N = Mg - F\sin\theta \qquad \text{.......(i)}$$

Friction force (f_r) = $F\cos\theta$

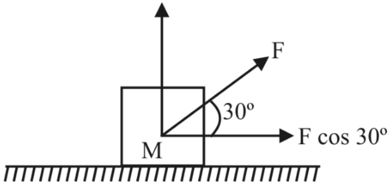
We know that, $f_r = \mu N$

$$\therefore \quad \mu N = F\cos\theta$$

Putting value of N from equation (i), we get –

$$\mu(Mg - F\sin\theta) = F\cos\theta$$
$$\mu Mg = F(\cos\theta + \mu\sin\theta)$$
$$F = \frac{\mu Mg}{(\cos\theta + \mu\sin\theta)}$$

599. In the diagram below, a body of mass M= 5kg placed on a horizontal surface is pulled by a force F= 40 N in a direction making an angle 30° with the horizontal. If g=10ms^{-2} and coefficient of friction between the body and surface is 0.2, the acceleration acquired by the body will be



(a) 5.75 ms^{-2}

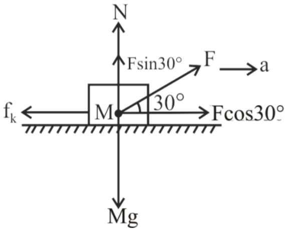
(b) 8.0 ms^{-2}

(c) 3.17 ms^{-2}

(d) 10.0 ms^{-2}

CG PET- 2011

Ans. (a) : Given, body of mass (M) = 5 kg , force (F) = 40N, coefficient of friction between body and surface (μ) = 0.2



From figure,

Resolving the forces along x and y direction

$\Sigma F_y = 0$

$$Mg = F\sin 30° + N$$
$$5 \times 10 = 40 \times \frac{1}{2} + N$$
$$N = 30N$$

We know that, $f_k = \mu N$

$$f_k = 0.2 \times 30 = 6 \text{ N}$$

@apna_pdf

Net horizontal force on body ($\Sigma F_x = 0$)

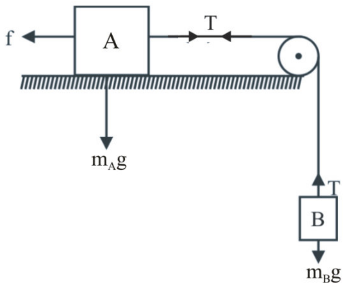
$$F\cos30° - f_k = Ma$$

$$40\times\frac{\sqrt{3}}{2} - 6 = 5\times a$$

$$a = \frac{20\sqrt{3}-6}{5}$$

$$a = 5.728 \text{ m/s}^2$$

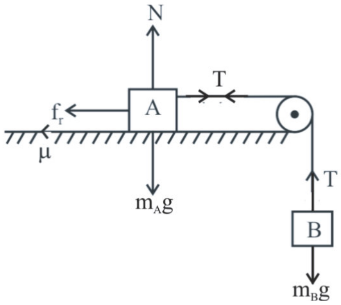
600. In the diagram below, a block A of mass 10 kg rests on a horizontal table. A mass-less string attached with it passes over a frictionless pulley attached at the end of table with another block B at its free end. If coefficient of friction between the block A and table surface is 0.2, the minimum mass of block B needed to start motion is block A is



(a) 2 kg (b) 0.2 kg
(c) 5 kg (d) 10 kg

CG PET- 2011

Ans. (a) : Given that, mass of block A (m_A) = 10 kg, mass of block B (m_B) = m, μ = 0.2



Consider block B, $m_Bg = T$ ….(i)

$N = m_Ag = 10 \times 10 = 100$

∵ $f_r = T = \mu N$

$T = 0.2 \times 100 = 20$ N …(ii)

From equation (i) and (ii), we get

$m_Bg = 20$

$m_B = \frac{20}{10}$ (∵ $g = 10 \text{ m/sec}^2$)

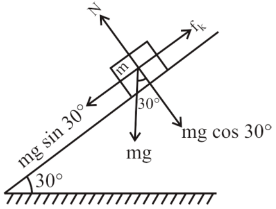
$m_B = 2$kg

601. A body is sliding down on a rough inclined plane which makes an angle of 30° with the horizontal. If the coefficient of friction is 0.26, the acceleration is m/s^2 is

(a) 1.95 (b) 2.78
(c) 3.47 (d) 4.6

CG PET- 2010

Ans. (b) : Given, θ = 30°, μ = 0.26



Let, body mass = m

From figure, N = mg cos 30°

$f_k = \mu N = \mu mg \cos 30°$

Net force along the inclined plane

$mg\sin30° - \mu mg\cos30° = ma$

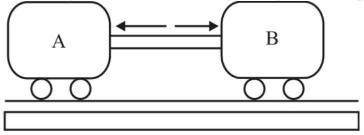
$g\sin30° - \mu g\cos30° = a$

$$10\times\frac{1}{2} - 0.26\times10\times\frac{\sqrt{3}}{2} = a$$

$5 - 2.252 = a$

$a = 2.75 \cong 2.78 \text{ m/sec}^2$

602. Two carts of masses 200 Kg and 300 kg on horizontal rails are pushed apart. Suppose the coefficient of friction between the carts and the rails are same. If the 200 kg cart travels a distance of 36 m and stops, then the distance travelled by the cart weighing 300 kg is



(a) 32 m (b) 24 m
(c) 16 m (d) 12 m

CG PET- 2007

Ans. (c) : Given that, mass of cart A (m_1) = 200kg, mass of cart B (m_2) = 300 kg, distance travels by A (S_1) = 36 m, distance travels by B (S_2) = ?

Let coefficient of friction = μ

By conservation of momentum

$m_1 v_1 = m_2 v_2$

$200v_1 = 300v_2$

$$\frac{v_1}{v_2} = \frac{300}{200} = \frac{3}{2} \quad …..(i)$$

We know that, work done against friction force is equal to kinetic energy of carts.

Friction force = μmg

Work done against friction force = μmgS

For cart A, $\frac{1}{2}m_1v_1^2 = \mu m_1 g S_1$ ...(ii)

For cart B, $\frac{1}{2}m_2v_2^2 = \mu m_2 g S_2$ ...(iii)

Equation (ii) divided by(iii), we get –

$$\frac{\frac{1}{2}m_1v_1^2}{\frac{1}{2}m_2v_2^2} = \frac{\mu m_1 g S_1}{\mu m_2 g S_2}$$

$$\frac{v_1^2}{v_2^2} = \frac{S_1}{S_2}$$

@apna_pdf

Putting the value of v_1/v_2, we get-

$$\left(\frac{3}{2}\right)^2 = \frac{36}{S_2}$$

$$S_2 = 36 \times \frac{4}{9}$$

$$S_2 = 16 \text{ m}$$

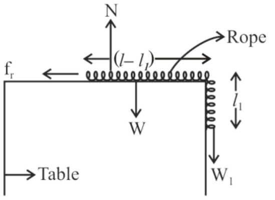
603. A uniform rope of length l lies on a table. If the coefficient of friction is μ then the maximum length l_1 of the part of this rope which can overhang from the edge of the table without sliding down is

(a) l/μ (b) $\frac{l}{\mu+1}$

(c) $\frac{\mu l}{1+\mu}$ (d) $\frac{\mu l}{\mu-1}$

CG PET- 2006

Ans. (c) : Given that, length of rope = l, length of overhang rope = l_1, coefficient of friction = μ



Let mass per unit length = P

Then, weight of $l_1 = Pl_1g$

Weight of non over hang rope (W) = $(l - l_1)$ Pg = N

Friction force = μN = μPg $(l - l_1)$

In equilibrium condition

Friction force = weight of l_1

$$\mu (l - l_1)Pg = l_1Pg$$

$$\mu l = l_1 + \mu l_1$$

$$l_1 = \frac{\mu l}{1+\mu}$$

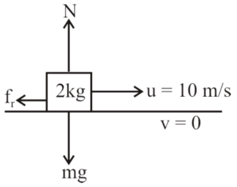
604. On a rough horizontal surface, a body of mass 2kg is given a velocity of 10m/s. If the coefficient of friction is 0.2 and g = 10m/s^2, the body will stop after covering a distance of

(a) 10 m (b) 25 m

(c) 50 m (d) 250 m

CG PET- 2005

Ans. (b) : Given that, mass of body (m) = 2kg, μ = 0.2, u = 10 m/s, v = 0



Friction force (f_r) = μN = μmg

Friction force is retarding force.

∴ ma = μ mg

$$a = \mu g = 0.2 \times 10 = 2 \text{ m/s}^2$$

Now,

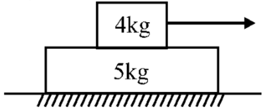
$$v^2 = u^2 - 2as$$

$$0 = (10)^2 - 2 \times 2s$$

$$s = \frac{100}{4} = 25\text{m}$$

s = 25 m

605. A large slab of mass 5kg lies on a smooth horizontal surface, with a block of mass 4kg lying on the top of it, the coefficient of friction between the block and the slab is 0.25. If the block is pulled horizontally by a force of F = 6N, the work done by the force of friction on the slab between the instants t = 2s and t = 3s is (g = 10 m/s^2)

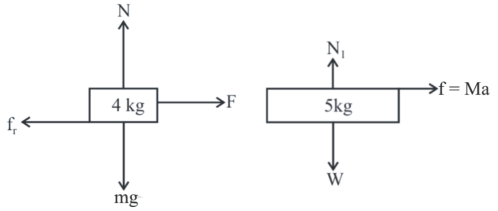


(a) 2.4 J (b) 5.55 J

(c) 4.44 J (d) 10 J

Manipal UGET-2015

Ans. (b) : Given that, mass of block (m) = 4kg, mass of slab (M) = 5 kg, μ = 0.25, F = 6 N



Friction force (f_r) = μN = μmg = 0.25 × 4 × 10 = 10 N

∵ $f_r > F$

So, block and slab move together as a single unit let acceleration of combined unit = a

Then, (M + m) a = F

(5 + 4) a = 6

$$a = \frac{6}{9} = \frac{2}{3} \text{ m/s}^2$$

Force on slab (f) = Ma

$$f = 5 \times \frac{2}{3} = \frac{10}{3}\text{N}$$

Work done by the force of friction on slab between the instants, t = 2s and t = 3s

W = f × displacement (Δs)

We know that, $S(t) = ut + \frac{1}{2}at^2$

For 3 sec

$$S(3) = 0 \times 3 + \frac{1}{2} \times \frac{2}{3} \times (3)^2$$

S (3) = 3 m

For 2 sec

$$S(2) = 0 \times 2 + \frac{1}{2} \times \frac{2}{3} (2)^2$$

$$S(2) = \frac{4}{3}\text{m}$$

Therefore work done by friction = f × ΔS

$$= \frac{10}{3} \times \left(3 - \frac{4}{3}\right) = \frac{50}{9} = 5.55 \text{ J}$$

@apna_pdf

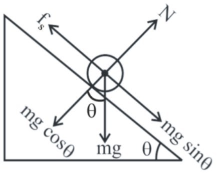
606. A solid cylinder is rolling down on an inclined plane of angle θ. The coefficient of static friction between the plane and the cylinder is μ_s. The condition for the cylinder not to slip is

(a) $\tan\theta \geq 3\mu_s$ (b) $\tan\theta > 3\mu_s$

(c) $\tan\theta \leq 3\mu_s$ (d) $\tan\theta < 3\mu_s$

Manipal UGET-2015

Ans. (c) : Given that, angle of inclined plane = θ, coefficient of friction = μ_s



Let, mass of cylinder = m

From figure, N = mg cosθ

Static friction force (f_s) = $\mu_s N = \mu_s$ mg cosθ ….(i)

General linear acceleration for rolling is

$$a = \frac{g\sin\theta}{1+\frac{k^2}{R^2}}$$

For solid cylinder $\left(\frac{k}{R}\right)^2 = \frac{1}{2}$

$$a = \frac{g\sin\theta}{\left(1+\frac{1}{2}\right)} = \frac{2}{3}g\sin\theta$$

The force of friction also cause a torque around the center of mass.

$$\tau = Rf_s = I\alpha \qquad \left(\because I = \frac{mR^2}{2}, a = R\alpha\right)$$

$$Rf_s = \frac{mR^2}{2}\alpha$$

$$f_s = \frac{ma}{2}$$

$$\therefore \quad f_s = \frac{m}{2}\times\frac{2}{3}g\sin\theta\left(\because a = \frac{2}{3}g\sin\theta\right)$$

$$f_s = \frac{m}{3}g\sin\theta..........(ii)$$

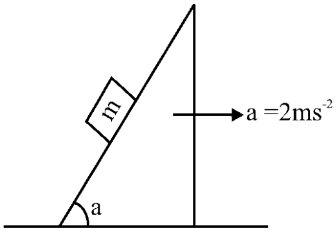
The condition for the cylinder not to slip is static friction ≥ Rolling friction.

$$\mu_s \, mg\cos\theta \geq \frac{m}{3}g\sin\theta$$

$$\mu_s \geq \frac{\tan\theta}{3}$$

$$3\mu_s \geq \tan\theta$$

607. A block of mass m is lying on the edge having inclination angle $\alpha = \tan^{-1}\left(\frac{1}{5}\right)$. Wedge is moving with a constant acceleration, α = 2ms^{-2}. The minimum value of coefficient of friction μ, so that m remains stationary with respect to wedge is

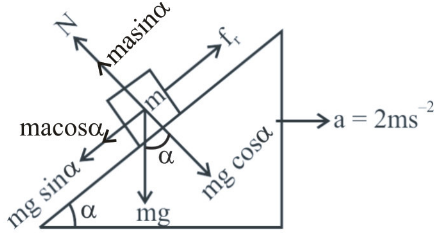


(a) $\frac{2}{a}$ (b) $\frac{5}{12}$

(c) $\frac{1}{5}$ **(d)** $\frac{2}{5}$

Manipal UGET-2015

Ans. (b) : Given, $\alpha = \tan^{-1}\left(\frac{1}{5}\right)$, mass of block = m, acceleration (a) = 2ms^{-2}, coefficient of friction = μ



From figure, mg sinα + ma cosα = f_r …..(i)

ma sinα + N = mg cosα

N = mg cos α – ma sinα

Friction force (f_r) = μN = μ (mg cosα – ma sinα)

Putting the value of f_r, we get-

mg sinα + ma cosα = μ (mg cosα – ma sinα)

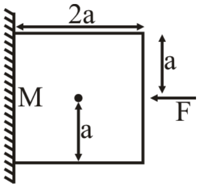
$$\mu = \frac{g\sin\alpha + a\cos\alpha}{g\cos\alpha - a\sin\alpha}$$

$$\mu = \frac{\cos\alpha(g\tan\alpha + a)}{\cos\alpha(g - a\tan\alpha)}$$

$$\mu = \frac{10\times\frac{1}{5}+2}{10-2\times\frac{1}{5}} \qquad \left(\because a = 2, \tan\alpha = \frac{1}{5}\right)$$

$$\mu = \frac{20}{48} = \frac{5}{12}$$

608. In the figure shown, a cubical block is held stationary against a rough wall by applying force 'F', then incorrect statement among the following is



(a) Frictional force f = Mg

(b) F = N, N is normal reaction

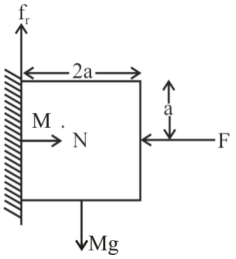
(c) F does not apply any torque

(d) N does not apply any torque

Manipal UGET-2014

@apna_pdf

Ans. (d) : From figure, friction force (f_r) = Mg

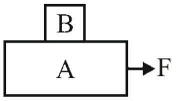


Since, N = F

F does not apply any torque because it act on centre of mass.

Normal force apply torque which is equal to torque due to friction force.

609. A body A of mass 1 kg rests on a smooth surface. Another body B of mass 0.2 kg is placed over A as shown. The coefficient of static friction between A and B is 0.15. B will begin to slide on A, if A is pulled with a force greater than



(a) 1.764 N (b) 0.1764 N
(c) 0.3 N (d) It will not slide for any F

Manipal UGET-2014

Ans. (a) : Given, M = 1 kg, m = 0.2 kg, $\mu_s = 0.15$

If A is pulled by force F the acceleration of system (A+B) is

$$a = \frac{F}{m+M}$$

B will begin to slide on A, if pseudo force (F_B) is more than limiting friction (F_s)

$$F_B > F_s$$

$$ma > \mu_S mg$$

$$m\left[\frac{F}{m+M}\right] > 0.15mg$$

$$F > 0.15g\,(m+M)$$

$$F > 0.15 \times 9.8 \times (0.2+1)$$

$$F > 1.764 \text{ N}$$

610. A car is moving along a straight horizontal road with a speed v_o. If the coefficient of friction between the tires and the road is μ, the shortest distance in which the car be stopped is

(a) $\frac{v_0^2}{\mu}$ (b) $\left(\frac{v_0}{\mu g}\right)^2$
(c) $\frac{v_0^2}{\mu g}$ (d) $\frac{v_0^2}{2\mu g}$

Manipal UGET-2013

Ans. (d) : Work done against frictional force is equals the kinetic energy of the body.

Kinetic energy of car $(K) = \frac{1}{2}mv_0^2$

$\therefore$ Kinetic energy = Work done against friction force

$$\frac{1}{2}mv_o^2 = \mu mgs$$

Shortest distance (s) = $\frac{v_0^2}{2\mu g}$

611. A body is coming with a velocity of 72 km/h on a rough horizontal surface with a coefficient of friction 0.5. If the acceleration due to gravity is 10 m/s^2, find the minimum distance it can be stopped.

(a) 400 m (b) 40 m
(c) 0.40 m (d) 4 m

Manipal UGET-2010

Ans. (b) : Given,

Initial velocity (u) = 72 km/h = 72 × 5/18 = 20 m/s, gravity (g) = 10 ms^{-2}, coefficient of friction (μ) = 0.5

Body is at static position, then last velocity (v) =0

Acceleration (a_{friction}) = μg = 0.5 × 10 = 5ms^{-2}

From equation of motion –

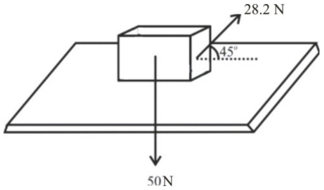
$$v^2 = u^2 - 2as$$

$$s = \frac{u^2 - v^2}{2a} = \frac{20^2 - 0}{2\times 5}$$

$$s = \frac{400}{10}$$

$$s = 40\text{m}$$

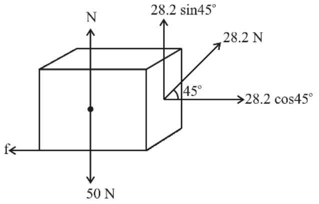
612. A body of weight 50 N placed on a horizontal surface is just moved by a force of 28.2 N. The frictional force and normal reaction are



(a) 2N, 3N (b) 5 N, 6N
(c) 10N, 15N (d) 20 N, 30 N

JCECE-2012

Ans. (d) :



In vertical direction –

$$N + 28.2 \sin 45^\circ = 50$$

$$N = 50 - 28.2 \times \frac{1}{\sqrt{2}}$$

$$N = 30.06 \text{ N} \approx 30 \text{ N}$$

In horizontal direction –

$$f = 28.2 \cos 45^\circ$$

$$f = 28.2 \times \frac{1}{\sqrt{2}}$$

$$f = 19.94 \text{ N} \approx 20 \text{ N}$$

@apna_pdf

613. A block B is pushed momentarily along a horizontal surface with an initial velocity V. If μ is the coefficient of sliding friction between B and the surface, block B will come to rest after a time

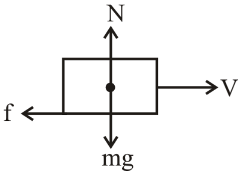
(a) $\frac{V}{g\mu}$ (b) $\frac{g\mu}{V}$

(c) $\frac{g}{V}$ (d) $\frac{V}{g}$

JIPMER-20016, 2014, 2009
UPCPMT-2008 / JCECE-2008
UPSEE-2007 / AIPMT-2007

Ans. (a) : Initial velocity = V, Final velocity = 0

The block B will be come to rest when –



Friction force = applied force

$\mu mg = ma$

$a = \mu g$

According to law of motion -

$\because \quad v = u - at$

$0 = V - at$

$$\boxed{t = \frac{V}{a} = \frac{V}{\mu g}}$$

614. A block of mass 10 kg is placed on a rough horizontal surface whose coefficient of friction is 0.5. If a horizontal force of 100 N is applied on it, then acceleration of block will be:

(a) $10 m/s^2$ (b) $5 m/s^2$

(c) $15 m/s^2$ (d) $0.5 m/s^2$

JCECE-2006
AIPMT-2002

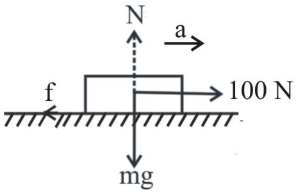
Ans. (b) : Given,

$m = 10$ kg

$g = 10 \text{ ms}^{-2}$

$\mu = 0.5$

$F = 100$ N



$\because \; N = mg = 10 \times 10$

In horizontal direction,

$100 - f = ma$

$100 - \mu N = ma$

$100 - 0.5 \times 10 \times 10 = 10\, a$

$10a = 100 - 50 \Rightarrow 50 = 10a$

$\Rightarrow a = 5 m/s^2$

615. A block of mass 2 kg rests on a plane inclined at an angle of 30° with the horizontal. The coefficient of friction between the block and surface is 0.7. The frictional force acting on the block is :

(a) 11.9 N (b) 25 N

(c) 50 N (d) 22.9 N

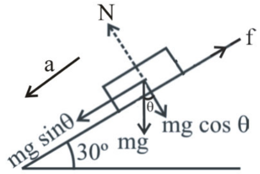
JCECE-2005
J&K CET-2004

Ans. (a) : Given,

$m = 2$ kg

$\theta = 30°$

$\mu = 0.7$



According to figure,

$f = mg \sin\theta$

$f = mg \sin 30°$

$f = 2 \times 9.8 \times \frac{1}{2}$

$f = 9.8$

Limiting friction force between the block and the inclined plane is given as –

$f_{lim} = \mu_s . N$

$= \mu_s .\, mg\cos 30°$

$= 0.7 \times 2 \times 9.8 \times \frac{\sqrt{3}}{2}$

$f_{lim} = 11.9$ N

The frictional force acting on the block is 11.9 N.

616. A block of mass 0.1 kg is held against a wall by applying a horizontal force of 5 N on it. If μ_s is between the wall and the block is 0.5, the magnitude of the frictional force acting on the block is

(a) 0.98 N (b) 0.49 N

(c) 4.9 N (d) 2.5 N

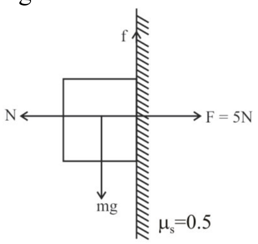
COMEDK 2012

Ans. (a) : Given,

$F = 5N$

$\mu_s = 0.5$

$m = 0.1$ kg



Hence, friction force acting on the block is –

$f = m.g$

$f = 0.1 \times 9.8$

$f = 0.98$ N

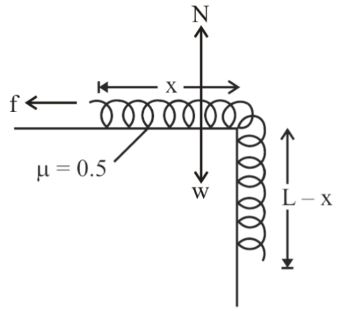
@apna_pdf

617. A uniform chain of length L is lying partly on a table, the remaining part hanging down from the edge of the table. If the coefficient of friction between the chain and the table is 0.5, what is the minimum length of the chain that should lie on the table, to prevent the chain from slipping down to the ground?

(a) L/3 (b) L/2
(c) 2L/3 (d) 3L/4

COMEDK 2015

Ans. (c) :



Let, x = length of the chain lies on the
M = mass of chain

mass per unit length of chain = $\frac{m}{L}$

mass of the length (L–x) of hanging chain = $\frac{m}{L}(L-x)$

mass of length x of the chain = $\frac{m}{L}x$

Friction force on the upper part = weight of hanging part.

Weight of length x of the chain = weight of length (L – x) of hanging chain

$$\mu.\frac{m}{L}x.g = \frac{m}{L}(L-x)g$$

$$\mu x = L - x$$

$$x(\mu+1) = L$$

$$x = \frac{L}{\mu+1}$$

$$x = \frac{L}{0.5+1}$$

$$x = \frac{2L}{3}$$

618. Assertion: Mountain roads rarely go straight up the slope.

Reason: Slope of mountains are large, therefore more chances of vehicle to slip from roads.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2016

Ans. (a) : Therefore, mountain roads rarely go straight up the slope because slope of mountain are large so there are more chances for vehicles to slip from roads.

619. Assertion: Use of ball bearings between two moving parts of a machine is common particle.

Reason: Ball bearings reduce vibrations and provide good stability.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2006

Ans. (c) : Ball bearing are used to reduce friction between moving part of machine.

Ball bearing are used to convert sliding friction into rolling friction because rolling friction is much lesser than sliding friction.

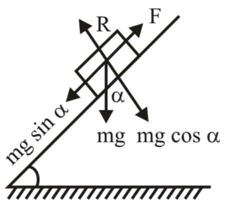
620. Assertion: Angle of repose is equal to the angle of limiting friction.

Reason: When the body is just at the point of motion, the force of friction in this stage is called limiting friction.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2008

Ans. (b) : The maximum value of static friction which is generated between two surface is known as the limiting friction.



Angle of repose is defined as the minimum angle of inclination of a plane with horizontal such that a body on the plane just begin to slide down.

In limiting condition,

@apna_pdf

F = mg sin α and R = mg cosα

Where, α- angle of repose

So, $\frac{F}{R} = \tan\alpha$

$$\therefore \quad \frac{F}{R} = \mu_s = \tan\theta = \tan\alpha \qquad (\because \tan\theta = \mu_s)$$

or $\theta = \alpha$

i.e., angle of friction = angle of repose

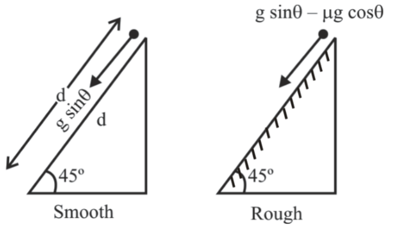
621. A smooth is released at rest on a 45° incline and then slides a distance 'd'. The time taken to slide is 'n' times as much to slide on rough incline than on a smooth incline. The coefficient of friction is

(a) $\mu_k = \sqrt{1 - \frac{1}{n^2}}$ (b) $\mu_k = 1 - \frac{1}{n^2}$

(c) $\mu_s = \sqrt{1 - \frac{1}{n^2}}$ (d) $\mu_s = 1 - \frac{1}{n^2}$

SCRA-2014
AIIMS-2016

Ans. (b) :



Smooth Rough

When surface is smooth –

$$d = \frac{1}{2}(g\sin\theta)t_1^2$$

When surface is rough –

$$d = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t_2^2$$

Time taken to the block slide on incline plane –

$$t_1 = \sqrt{\frac{2d}{g\sin\theta}}, \quad t_2 = \sqrt{\frac{2d}{g\sin\theta - \mu g\cos\theta}}$$

According to question, $t_2 = nt_1$

$$n\sqrt{\frac{2d}{g\sin\theta}} = \sqrt{\frac{2d}{g\sin\theta - \mu g\cos\theta}}$$

μ_k, applicable here, is coefficient of kinetic friction as the block moves over the inclined plane.

$$n = \frac{1}{\sqrt{1-\mu_k}} \qquad \left(\because \cos 45^\circ = \sin 45^\circ = \frac{1}{\sqrt{2}}\right)$$

$$n^2 = \frac{1}{1-\mu_k} \quad \text{or} \quad 1 - \mu_k = \frac{1}{n^2}$$

$$\text{or } \mu_k = 1 - \frac{1}{n^2}$$

622. When the two surfaces are coated with the lubricant, then they will:

(a) slide upon each other (b) stick to each other

(c) roll upon each other (d) none of these

AIIMS-2001

Ans. (a) : Friction prevents relative motion between two surface. If two surface are coated with lubricant then friction will be reduced so they can slide over each other if one is pushed on the other.

623. If the coefficient of static friction between the tyres and road is 0.5, what is the shortest distance in which an automobile can be stopped when travelling at 72km/h?

(a) 50m (b) 60m

(c) 40.8m (d) 80.16m

BCECE-2007

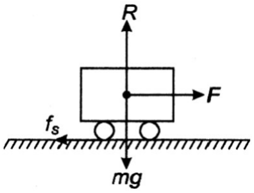
Ans. (c) : Given,

$v = 0$

$u = 72 \text{ km/h} = 20 \text{ m/s}$

$g = 9.8 \text{m/s}^2$

Here, frictional force working between road and tyres which is retards the motion of automobile. The static friction (f_s) working between tyres and road, so frictional force cause the retardation in velocity of automobile.



Hence,

$$F = f_s = \mu R$$
$$= \mu.mg$$

Where m is the mass of automobile

We know that,

$$F = ma$$
$$\mu mg = ma$$
$$a = \mu g$$
$$a = 0.5g$$

Retardation is 0.5g

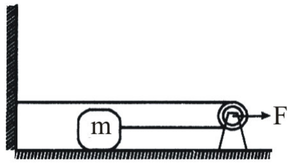
Let automobile stops at a distance x, then from third equation of motion-

$$v^2 = u^2 - 2as$$

$$\therefore \quad 0^2 = (20)^2 - 2\times(0.5\times9.8)x$$

$$x = \frac{20\times20}{2\times0.5\times9.8} = 40.8\text{m}$$

624. In the given figure the pulley is assumed massless and frictionless. If the friction force on the object of mass m is f, then its acceleration in terms of the force F will be equal to :



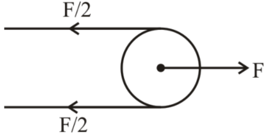
(a) $(F - f)/m$ (b) $\left(\frac{F}{2} - f\right)/m$

(c) F/m (d) none of these

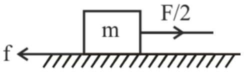
BCECE-2006

@apna_pdf

Ans. (b) : As the pulley is mass-less and frictionless, net force on pulley will be zero.



According to question –



$$\frac{F}{2} - f = ma$$

$$a = \frac{\left(\frac{F}{2} - f\right)}{m}$$

625. A body is moving along a rough horizontal surface with an initial velocity 6 m/s. If the body comes to rest after travelling a distance 9 m, then the coefficient of sliding friction will be:

(a) 0.4 (b) 0.2
(c) 0.6 (d) 0.8

BCECE-2004

Ans. (b) : Given,
Initial velocity (u) = 6 m/s, s = 9 m, μ_s = ?
We know that,

$$F = \mu_s.N = \mu_s.mg$$

If acceleration of body is a
Then,

$$F = \mu_s.\ mg$$
$$m.a = \mu_s.mg$$
$$\mu_s = \frac{a}{g}$$

Where, μ_s is sliding friction.
Apply equation of motion –

$$v^2 = u^2 + 2as$$
$$0 = (6)^2 + 2a \times 9$$
$$-36 = 18a$$

$a = -2\ m/s^2$ (–ve sign indicate body is retarding)
Hence, coefficient of sliding friction is –

$$\mu_s = \frac{a}{g} = \frac{2}{10} = 0.2$$

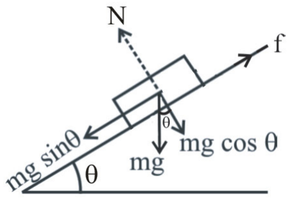
626. An object is placed on the surface of a smooth inclined plane of inclination θ. It takes time *t* to reach the bottom. If the same object is allowed to slide down a rough inclined plane of inclination θ, it takes time nt to reach the bottom, where *n* is a number greater than 1. The coefficient of friction μ is given by–

(a) $\mu = \tan\theta\left(1 - \frac{1}{n^2}\right)$ (b) $\mu = \cos\theta\left(1 - \frac{1}{n^2}\right)$

(c) $\mu = \tan\theta\sqrt{1 - \frac{1}{\sqrt{n^2}}}$ (d) $\mu = \cot\theta\sqrt{1 - \frac{1}{n^2}}$

BCECE-2010

Ans. (a) :



On smooth inclined plane –
Acceleration of the body (a) = g sin θ
If s be the distance travelled, then apply equation of motion –

$$s = ut + \frac{1}{2}at^2 \qquad [u = 0]$$

$$s = \frac{1}{2}g\sin\theta \times t_1^2 \qquad \text{..... (i)}$$

On rough inclined plane –
Acceleration is-

$$a = \frac{mg\sin\theta - \mu R}{m}$$

or $$a = \frac{mg\sin\theta - \mu\, mg\cos\theta}{m}$$

$$a = g\sin\theta - \mu g\cos\theta$$

Apply equation of motion –

$$s = ut + \frac{1}{2}at^2 \qquad [u = 0]$$

$$\therefore \quad s = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t_2^2 \qquad \text{..... (ii)}$$

From equation (i) and (ii), we get –

$$\frac{t_2^2}{t_1^2} = \frac{g\sin\theta}{g\sin\theta - \mu g\cos\theta} \qquad \text{....(iii)}$$

But $t_2 = nt_1$
Squaring both side-

$$t_2^2 = n^2 t_1^2$$
$$n^2 = \frac{t_2^2}{t_1^2}$$

From equation (iii), we get -

$$\therefore \quad n^2 = \frac{\sin\theta}{\sin\theta - \mu\cos\theta}$$

$\Rightarrow n^2\sin\theta - n^2\mu\cos\theta = \sin\theta$
$\Rightarrow (n^2 - 1)\sin\theta = n^2\cos\theta\ \mu$

or $$\mu = \frac{(n^2 - 1)}{(n^2)} \times \frac{\sin\theta}{\cos\theta}$$

or $$\mu = \left(1 - \frac{1}{n^2}\right)\tan\theta$$

627. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10s. Then the coefficient of friction is (Take g= 10ms^{-2})

(a) 0.06 (b) 0.03
(c) 0.04 (d) 0.01

VITEEE-2016

@apna_pdf

Ans. (a) : Given,

$u = 6 m/s$, $v = 0$, $t = 10 s$, $m = 2$ kg

We know that,

$$f = ma$$
$$\mu.N = ma$$
$$\mu.mg = ma$$
$$a = -10\mu \qquad \text{(For retardation)}$$

From equation of motion –

$$v = u + at$$
$$0 = 6 + (-10\mu.10)$$
$$-6 = -100\mu$$
$$\mu = 0.06$$

628. A bullet of mass 0.02 kg travelling horizontally with velocity 250 ms^{-1} strikes a block of wood of mass 0.23 kg which rests on a rough horizontal surface. After the impact, the block and bullet move together and come to rest after travelling a distance of 40m. The coefficient of sliding friction of the rough surface is (g = 9.8 ms^{-2})

(a) 0.75 (b) 0.61

(c) 0.51 (d) 0.30

VITEEE-2009

Ans. (c) : After collision the bullet and block move together and comes to rest after covering a distance of 40m.

Given, $m_1 = 0.02$ kg, $u_1 = 250$ m/s, $m_2 = 0.23$ kg, $u_2 = 0$

$v_1 = v_2 = v$, $d = 40$ m

According to the law of conservation of momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Or $0.02\times250 + 0.23 \times 0 = 0.02v + 0.23v$

$$5 + 0 = (0.25)\ v$$
$$v = \frac{500}{25} = 20 m/s$$

Applying conservation of energy

$$\frac{1}{2}mv^2 = \mu R.d$$
$$\frac{1}{2}(m_1 + m_2)v^2 = \mu R.d \qquad (\because R = mg)$$
$$\frac{1}{2}\times 0.25 \times 400 = \mu \times 0.25 \times 9.8 \times 40$$
$$\mu = \frac{200}{9.8\times 40}$$
$$= 0.51$$

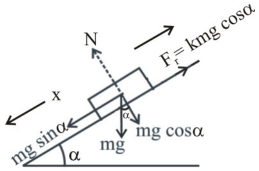
629. A small bar starts sliding down on inclined plane making an angle α with the horizontal. The coefficient of friction k depends on the distance *x* as k = *ax* where *a* is a constant. The distance covered by the bar till it stops is

(a) $\frac{(\tan\alpha)}{a}$ (b) $\frac{2(\tan\alpha)}{a}$

(c) 2a tan α (d) $\frac{\tan\alpha}{(2a)}$

SCRA-2014

Ans. (b) :



By the Newton's second law

$$F_x = m \times a_x$$

From figure,

$$mg\sin\alpha - kmg\cos\alpha = ma_x$$
$$a_x = g\sin\alpha - kg\cos\alpha$$

We know that,

$$a_x = \frac{dv}{dt}\times\frac{dx}{dx}$$
$$a_x = \frac{vdv}{dx}$$

or $$v\frac{dv}{dx} = g\sin\alpha - axg\cos\alpha, \text{ (as } k = ax)$$

or $$\int_0^v vdv = \int_0^x (g\sin\alpha - axg\cos\alpha)dx$$

So, $$\frac{v^2}{2} = g\left[\sin\alpha x - \frac{x^2}{2}a\cos\alpha\right]_0^x \text{ …….(i)}$$

$$0 = g(x\sin\alpha - a\cos\alpha.\frac{x^2}{2})$$
$$xg(\sin\alpha - a\cos\alpha.\frac{x}{2}) = 0$$
$$\sin\alpha - a\cos\alpha.\frac{x}{2} = 0$$
$$\sin\alpha = \frac{a\cos\alpha.x}{2}$$
$$2\sin\alpha = a\cos\alpha.x$$
$$x = \frac{2}{a}\tan\alpha$$

630. The frictional force on a rolling cylinder is proportional to

(a) the tangential force and directed perpendicular to the surfaces in contact

(b) the tangential force and directed parallel to the surfaces in contact

(c) the normal force and directed parallel to the surfaces in contact

(d) the normal force and directed perpendicular to the surface in contact

SCRA-2014

Ans. (c) : The frictional force on a rolling cylinder is proportional to the normal force and directed parallel to the surfaces is in contact.

631. A body of mass m slides down a rough plane of inclination α. If μ is the coefficient of friction, then the acceleration of the body will be

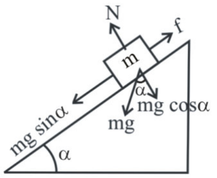
(a) g sin α (b) μ cos α

(c) g (sin α - μ cos α) (d) g (cos α - μ sin α)

SCRA-2013

@apna_pdf

Ans. (c) :



Where, f = friction force

N = Normal force

N = mg cos α

Net force, $F_{net} = ma = mg \sin\alpha - f$ ....(i)

∵ Friction force $f = \mu N = \mu\, mg \cos\alpha$

By puting this value in equation (i) we get

$F_{net} = ma = mg \sin\alpha - \mu mg \cos\alpha$

$a = g \sin\alpha - \mu g \cos\alpha$

The acceleration, $a = g(\sin\alpha - \mu \cos\alpha)$

632. How will coefficient of friction change if the normal reaction is halved?

(a) Doubled

(b) Halved

(c) Unchanged

(d) Cannot be predicted

SCRA-2013

Ans. (c) : When normal reaction is halved the coefficient of friction is unchanged because, the coefficient of friction is a property of the two surfaces in contact. If we double the normal force, we double the amount of friction, but the coefficient of frictions will be same.

Note- Coefficient of friction depend upon the roughness or smoothness of surface in contact and act tangentially to the inter face between them.

633. A small object placed on a rotating horizontal turn table just slips when it is placed at a distance 9 cm from the axis of rotation. If the angular velocity of the turn table is tripled the object slips when its distance from the axis of rotation is :

(a) 1 cm (b) 2 cm

(c) 4 cm (d) 9 cm

SCRA-2012

Ans. (a) : If a small object placed on a rotating horizontal turning table then there will be centripetal force acting on object-

$F_c = mr\omega^2$

Where, m = mass of body

r = distance from the axis of rotation

ω = angular velocity of rotation

And there will be 'μ' (coefficient of friction) due to contact between table and object.

The object will be slip if centripetal force equal to the force of friction

Friction force (f) = μ mg

$F_c = f$

$mr\omega^2 = \mu mg$

$r\omega^2 = \mu g$ = constant,

$$\left[r \propto \frac{1}{\omega^2}\right]$$

$$\frac{r_1}{r_2} = \left(\frac{\omega_2}{\omega_1}\right)^2 \quad ----(i)$$

∵ $r_1 = 9\text{cm}$ (given)

$\omega_1 = \omega$

$\omega_2 = 3\omega$

$$\frac{9}{r_2} = \left(\frac{3\omega}{\omega}\right)^2 \qquad \frac{9}{r_2} = 9$$

$r_2 = 1$ cm

634. An insect crawls up a hemispherical surface very slowly. The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of hemispherical surface and the insect makes an angle α with the vertical, what is the maximum value of α?

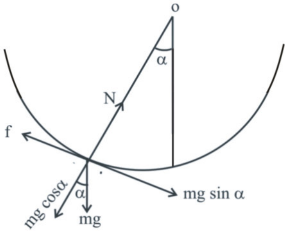
(a) $\cot^{-1} 3$ (b) $\tan^{-1} 3$

(c) $\sec^{-1} 3$ (d) $\text{cosee}^{-1} 3$

SCRA-2012

Ans. (a) :

From balancing the force:-



$N = mg \cos\alpha$ .... (i)

$f = mg \sin\alpha$ .... (ii)

∵ $f = \mu N$

From equation (i) and (ii) we get

$\mu mg \cos\alpha = mg \sin\alpha$

$$\mu = \frac{\sin\alpha}{\cos\alpha}$$

$\mu = \tan\alpha$

∵ $\mu = \frac{1}{3}$ (given)

$$\frac{1}{3} = \tan\alpha$$

$$\frac{1}{3} = \frac{1}{\cot\alpha}$$

Hence, insect makes an angle α,

$\cot\alpha = 3$

$\alpha = \cot^{-1}3$

635. A small body was launched up an inclined plane set at an angle θ against the horizontal. If the time of ascent of the body is k times less than the time of descent. What is the coefficient of friction?

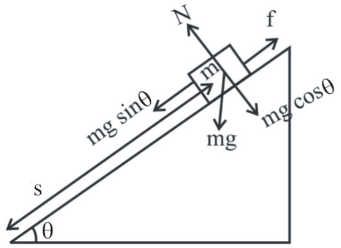
(a) $\left(\frac{k^2-1}{k^2+1}\right)\tan\theta$ (b) $\left(\frac{k^2+1}{k^2-1}\right)\tan\theta$

(c) $\left(\frac{k-1}{k+1}\right)\tan\theta$ (d) $\left(\frac{k+1}{k-1}\right)\tan\theta$

SCRA-2010

@apna_pdf

Ans. (a) : Case: (1)- When the body is launched up:



Consider, μ = coefficient of friction,
u = velocity of projection
s = distance along

Now retarding force on the block –

$$F = ma = mg\sin\theta + \mu\, mg\cos\theta$$

$$a = g(\sin\theta + \mu\cos\theta) \qquad .....(i)$$

by 2nd equation of motion

$$s = ut + \frac{1}{2}at^2$$

Initially, u = 0, and by equation (i),

$$s = 0 + \frac{1}{2}g(\sin\theta + \mu\cos\theta)t^2$$

$$s = \frac{1}{2}gt^2_{ascent}(\sin\theta + \mu\cos\theta) \qquad ....(ii)$$

Case (ii) – When block comes downward direction:-

$$f = ma = mg\sin\theta - \mu\, mg\cos\theta$$

$$a = g\sin\theta - \mu g\cos\theta \qquad ....(iii)$$

$$s' = ut + \frac{1}{2}at^2$$

Now by equation (iii),

$$s' = \frac{1}{2}g(\sin\theta - \mu\cos\theta)t^2_{descent------} \text{ (iv)}$$

From equation (ii) and (iv), we get –

And, $t_{ascent} = \frac{1}{k}t_{descent}$

$s' = s$

$$\frac{1}{2}g(\sin\theta + \mu\cos\theta)t^2_{ascent} = \frac{1}{2}g(\sin\theta - \mu\cos\theta)t^2_{descent}$$

$$(\sin\theta + \mu\cos\theta) \times \frac{1}{k^2} = (\sin\theta - \mu\cos\theta)$$

Divided by cosθ in both side:-

$$\left(\frac{\sin\theta}{\cos\theta} + \mu\right).\frac{1}{k^2} = \left(\frac{\sin\theta}{\cos\theta} - \mu\right)$$

$$(\tan\theta + \mu)\frac{1}{k^2} = (\tan\theta - \mu)$$

$$\tan\theta + \mu = k^2\tan\theta - \mu k^2$$

$$\mu(1 + k^2) = \tan\theta(k^2 - 1)$$

$$\mu = \tan\theta\left(\frac{k^2 - 1}{k^2 + 1}\right)$$

Hence, coefficient of friction $\mu = \tan\theta\left(\frac{k^2 - 1}{k^2 + 1}\right)$

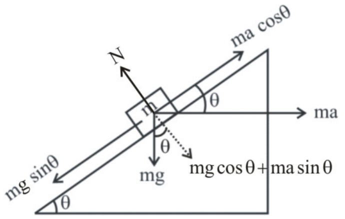
636. A body kept on a smooth inclined plane having inclination 1 in *l* will remain stationary relative to the inclined plane if the plane is given a horizontal acceleration equal to

(a) $\frac{g}{\sqrt{l^2 - 1}}$ (b) $\frac{gl}{\sqrt{l^2 - 1}}$

(c) $\frac{g}{2\sqrt{l^2 - 1}}$ (d) $\frac{2g}{\sqrt{l^2 - 1}}$

SCRA-2009

Ans. (a) :



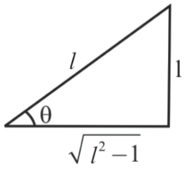
From free body diagram (FBD)

$$ma\cos\theta = mg\sin\theta$$

$$a = g\frac{\sin\theta}{\cos\theta} = g\tan\theta \qquad ....(i)$$

Given: $\sin\theta = \frac{1}{l}$

$$\tan\theta = \frac{1}{\sqrt{l^2 - 1}} \qquad ....(ii)$$



∴ From equation (i) and (ii), we get –

$$a = g\frac{1}{\sqrt{l^2 - 1}}$$

$$a = \frac{g}{\sqrt{l^2 - 1}}$$

637. Maximum acceleration of the train in which a 50kg box lying on its floor will remain stationary (Given, coefficient of static friction between the box and the train's floor is 0.3 and g = 10 ms^{-2}) :

(a) 5.0 ms^{-2} (b) 3.0 ms^{-2}

(c) 1.5 ms^{-2} (d) 15 ms^{-2}

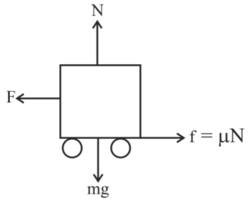
Karnataka CET-2016

Ans. (b) : Given, mass of the box (m) = 10 kg

Coefficient of friction (μ) = 0.3

Acceleration due to gravity(g) = 10m/s^2

Net force,



@apna_pdf

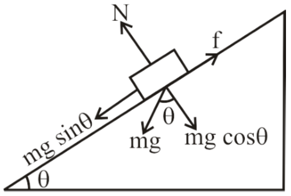
Friction force $f = \mu N$
Normal force $N = mg$
$f = mg\mu$
ma = pseudo force acting opposite to motion of train to make it stationary
$ma = \text{friction force}$
$ma = \mu mg$
$a = \mu g$
$a = 0.3 \times 10$
$a = 3\text{m/s}^2$
Hence, the maximum acceleration of the train will be (3ms^{-2}).

638. A cubical block rests on an inclined plane of coefficient of friction $\mu = \frac{1}{\sqrt{3}}$. What should be the angle of inclination so that the block just slides down the inclined plane?

(a) 30° (b) 60°
(c) 45° (d) 90°

J&K CET- 2011

Ans. (a) : Given, $\mu = \frac{1}{\sqrt{3}}$ ….. (i)
Angle of inclination θ



The block will have force mg sinθ along the incline plane and the frictional force will have
$f = \mu N$
Where, $N = mg\cos\theta$
For equilibrium –
$f = mg\sin\theta$
$\therefore \quad \mu mg\cos\theta = mg\sin\theta$
$\tan\theta = \mu$
$\tan\theta = \frac{1}{\sqrt{3}}$ (from (i))
$\theta = \tan^{-1}\frac{1}{\sqrt{3}}$
$\theta = 30°$
Hence, angle of inclination θ = 30°

639. An object placed on an inclined plane starts sliding when the angle of incline becomes 30^0. The coefficient of static friction between the object and the plane is

(a) $\frac{1}{\sqrt{3}}$ (b) $\sqrt{3}$
(c) $\frac{1}{2}$ (d) $\frac{\sqrt{3}}{2}$

J&K CET- 2010

Ans. (a) : Inclination angle, θ = 30°
Coefficient of static friction μ_s = ?
We know that,
$\mu_s = \tan\theta$
$\therefore \quad \mu_s = \tan 30°$
$\mu_s = \frac{1}{\sqrt{3}}$
Hence, coefficient of static friction, $\mu_s = \frac{1}{\sqrt{3}}$

640. With increase of temperature, the frictional force acting between two surfaces

(a) increases (b) remains the same
(c) decreases (d) becomes zero

J&K CET- 2007

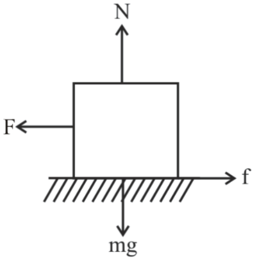
Ans. (b) : Friction, which acts between the contact of two surfaces, it means friction is the function of roughness of surface and force acting on it.
With increase in temperature the frictional force acting between the two surface remains the same.

641. A block of mass 2kg rests on a horizontal surface. If a horizontal force of 5N is applied on the block the frictional force on it is ($\mu_k = 0.4, \mu_s = 0.5$)

(a) 5 N (b) 10 N
(c) 8 (d) zero

J&K CET- 2006

Ans. (a) : Given , block mass (m) = 2 kg
Horizontal force (F) = 5N
Frictional force (f_s) = ?



From FBD
$N = mg$
$f = F_{net}$
The frictional force is calculated using the formula –
$f_s = \mu_s N$
$f_s = \mu_s mg = 0.5 \times 2 \times 10$
$f_s = 10\text{N}$
Here, we see that the frictional force is greater than the applied force, i.e. $f_s > F$
So, frictional force will adjust its value and will be equal to applied horizontal force
Frictional force, f = 5 N

642. An inclined plane has an inclination θ with horizontal. A body of mass m rests on it. If the coefficient of friction between the body and the plane is μ. Then the minimum force that needs to be applied parallel to the inclined plane is

(a) mgsinθ (b) μmgcosθ
(c) μmgcosθ + mgsinθ (d) μmgcosθ – mgsinθ

J&K CET- 2016, 2003

@apna_pdf

Ans. (c) : Given,

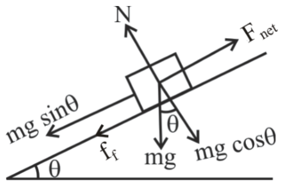
Inclination = θ with horizontal

mass = m at rest

Coefficient of friction = μ

Minimum force, parallel to the inclined plane = ?

From FBD



$N = mg\cos\theta$

$f = mg\sin\theta$

$f_f = \mu N = \mu mg\cos\theta$

Net force,

$f_{net} = f_f + f$

$f_{net} = \mu mg\cos\theta + mg\sin\theta$

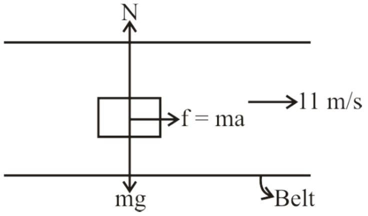
643. An object is gently placed on a long converges belt moving with $11ms^{-1}$. If the coefficient of friction is 0.4, then the block will slide in the belt up to distance of

(a) 10.21 m (b) 15.43 m

(c) 20.3 m (d) 25.6 m

J&K-CET-2014

Ans. (b) : Given,



Velocity of moving belt (u) = 11m/s

Coefficient of friction (μ) = 0.4

Net force, $f_{net} = ma = f_f$

$ma = \mu N$

$ma = \mu mg$

$a = \mu g$ ....(i)

$\because$ $\mu = 0.4$, $g = 10\ m/s^2$

$a = 0.4 \times 10 = 4\ m/s^2$

Velocity, u = 11m/s

v = 0

From equation of motion,

$v^2 = u^2 - 2as$

$0 = (11)^2 - 2 \times 4 \times s$

$$s = \frac{121}{8} = 15.125m$$

Hence, the block will slide to a distance of 15.125m.

644. Two blocks, of mass 1kg and 2 kg respectively, are connected by a spring and kept on a frictionless table. The blocks are pulled apart, so that the spring is stretched, and released from rest. At a certain instant of time, the block of mass 1 kg, is found to be moving at a speed 2m/s. What must be the speed of the other block at this instant?

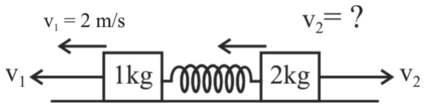
(a) 1 m/s (b) 0.5m/s

(c) 4 m/s (d) 0.25 m/s

J&K-CET-2012

Ans. (a) : Given, mass (m_1) =1kg, mass (m_2) = 2kg

Initial momentum = 0



According to law of conservation of momentum,

Initial momentum = Final momentum

$0 = m_1v_1 + m_2v_2$

$$v_2 = -\frac{m_1v_1}{m_2}$$

$$v_2 = -\frac{1\times2}{2}$$

$v_2 = -1m/s$

This negative sign shows that 2 kg is pulled in opposite direction to that of mass 1 kg.

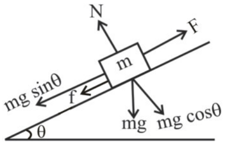
645. A block of mass m is place on an inclined plane having coefficient of friction μ. The plane is making an angle θ with horizontal. The minimum value of upward force acting along the incline that can just move the block up is

(a) mgcosθ (b) μmgcosθ

(c) mgsinθ (d) μmgsinθ

J&K-CET-2015

Ans. (c) : Minimum force required to move upward direction,



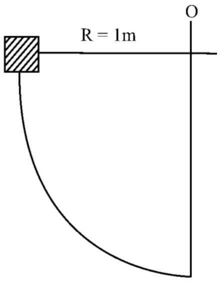
Frictional force = f_f = 0 (minimum)

$f_{min} = mg\sin\theta + f_f$

$= mg\sin\theta + 0$

$\therefore$ $f_{min} = mg\sin\theta$

646. A block of mass 1 kg slides down a curved track that is one quadrant of a circle of radius 1m. Speed of the block at the bottom is 2 m/s. Work done by the frictional force on the block when it reaches at the bottom is



(a) 8 J (b) –8 J

(c) 4 J (d) 8 J

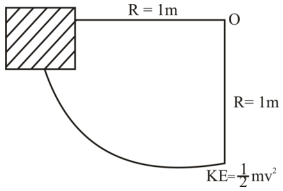
Manipal UGET-2016

@apna_pdf

Ans. (b) : Given,

$m = 1kg, v = 2m/s, h = R = 1m$

P.E. = mgh



From, energy conservation-

P.E. + W = K.E.

$$mgh + W = \frac{1}{2}mv^2$$

$$W = \frac{1}{2}mv^2 - mgh$$

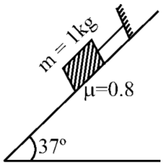
$$W = \frac{1}{2} \times 1 \times 2^2 - 1 \times 10 \times 1$$

$$W = 2 - 10$$

$$W = -8$$

Now, work done is – 8 Joule.

647. In the arrangement, the minimum value of tension in the string to prevent it from sliding down is

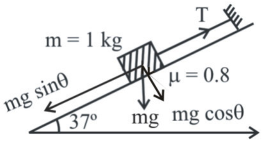


(a) 6 N (b) 8 N

(c) 10.8 N (d) zero

Manipal UGET-2016

Ans. (d) : Given, $m = 1$ kg, $\mu = 0.8$, $\theta = 37^o$,



Limiting friction along the plane

$= \mu_s$ mg cos θ

$= 0.8 \times 1 \times 10 \times \cos 37^o$

$= 8 \cos 37^o = 8 \times 0.79 = 6.38$ N

= 6.4 N

Force responsible for downward motion-

= mg sin θ

$= 1 \times 10 \times \sin 37°$

$= 1 \times 10 \times 0.60 = 6$ N

= 6 N

The full force of friction is not used. Therefore even without the string, the body will remain at rest hence tension is zero.

648. What will be the maximum speed of a car on a road turn of radius 30 m, if the coefficient of friction between the tyres and the road is 0.4? (Take $g = 9.8m/s^2$)

(a) 10.84 m/s (b) 9.84 m/s

(c) 8.84 m/s (d) 6.84 m/s

AIPMT- 1995

Ans. (a) : Given, $r = 30$ m, $g = 9.8$ m/s^2

The coefficient of friction between the tyres and the road (μ) = 0.4

The maximum speed

$$v_{max} = \sqrt{\mu gr}$$

$$= \sqrt{0.4 \times 9.8 \times 30}$$

$$= \sqrt{117.6}$$

$$= 10.84 \text{ m/s}$$

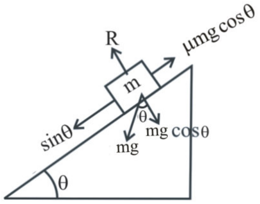
649. The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom, if the coefficient of friction between the block and lower half of the plane is given by

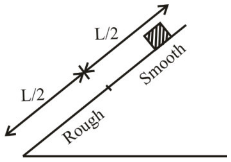
(a) $\mu = \frac{1}{\tan\theta}$ (b) $\mu = \frac{2}{\tan\theta}$

(c) $\mu = 2\tan\theta$ (d) $\mu = \tan\theta$

NEET- 2013

Ans. (c) :





For upper half smooth incline component of g down the incline -

= mgsinθ

We know,

$$v^2 = u^2 + 2as$$

$$\therefore \quad v^2 = 2(mg\sin\theta)\frac{L}{2}$$

For lower half rough incline, frictional retardation

= μmgcosθ

∴ Resultant acceleration = mgsinθ – μmgcosθ

$$\therefore \quad u^2 = v^2 + 2as$$

$$0 = v^2 + 2(mg\sin\theta - \mu mg\cos\theta)\frac{L}{2}$$

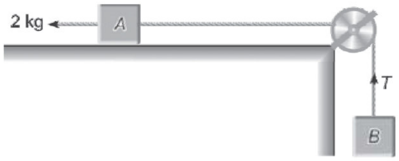
$$0 = 2(mg\sin\theta)\frac{L}{2} + 2mg(\sin\theta - \mu\cos\theta)\frac{L}{2}$$

$$0 = \sin\theta + \sin\theta - \mu\cos\theta$$

$$\mu\cos\theta = 2\sin\theta$$

$$\mu = 2\tan\theta$$

650. The coefficient of static friction, μ_s, between block A of mass 2 kg and the table as shown in the figure, is 0.2.What would be the maximum mass value of block B, so that the two blocks do not move ? The string and the pulley are assumed to be smooth and massless ($g = 10m/s^2$)



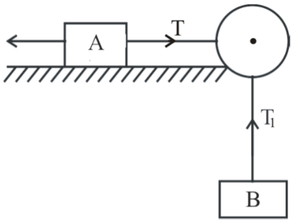
@apna_pdf

(a) 2.0 kg (b) 4.0 kg
(c) 0.2 kg (d) 0.4 kg

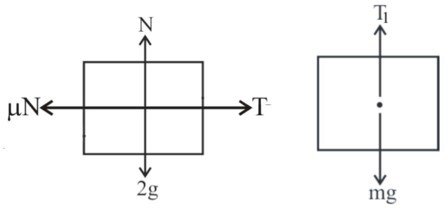
AIPMT- 2004

Ans. (d) : Given, mass of block A = 2kg

$\mu = 0.2$



Though the block does not move therefore, the tension in the string must equal to the force of friction on block A



$T = \mu N$ $\quad$ $T_1 = mg$

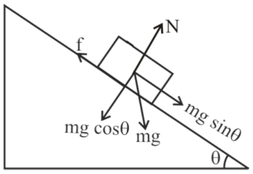
$$\therefore \quad T_1 = T$$
$$mg = \mu N$$
$$mg = \mu(2g)$$
$$m = 2\mu = 2\times0.2 = 0.4\,kg$$

651. A block has been placed on an inclined plane with the slope angle θ, block slides down the plane at constant speed. The coefficient of kinetic friction is equal to

(a) sinθ (b) cosθ
(c) g (d) tanθ

AIPMT- 1993

Ans. (d) :



By diagram –

Friction force (f) = μN

And $N = mg\cos\theta$

$f = \mu mg\cos\theta$

In equilibrium,

$$mg\sin\theta = f$$
$$mg\sin\theta = \mu mg\cos\theta$$

Or $\mu = \dfrac{\sin\theta}{\cos\theta} = \tan\theta$

652. Consider, a car moving along a straight horizontal road with a speed of 72 km/h. If the coefficient of static friction between the tyres and the road is 0.5, the shortest distance in which the car can be stopped is (Take g = 10m/s^2)

(a) 30 m (b) 40 m
(c) 72 m (d) 20 m

AIPMT- 1992

Ans. (b) : Given,

$$v = 72\,km\,h^{-1} = 72\times\frac{5}{18} = 20\,m/s^{-1}$$
$$\mu = 0.5 \text{ and } g = 10\,m\,s^{-2}$$

Initial kinetic energy of the car $= \dfrac{1}{2}mv^2$

Work done against friction = μ mgS

From conservation of energy

$$\mu mgS = \frac{1}{2}mv^2$$
$$\Rightarrow \quad S = \left(\frac{v^2}{2\mu g}\right)$$

∴ Stopping distance, $S = \left(\dfrac{v^2}{2\mu g}\right)$

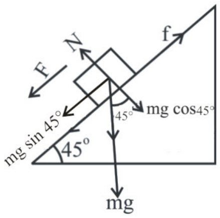
$$\therefore S = \frac{20\times20}{2\times0.5\times10} = 40m$$

653. Starting from rest, a body slides down a 45° inclined plane in twice the time it takes to slide down the same distance in the absence of friction. The coefficient of friction between the body and the inclined plane is

(a) 0.80 (b) 0.75
(c) 0.25s (d) 0.33

AIPMT- 1988
BCECE-2016

Ans. (b) : The various forces eating on the body have been shown in the figure. The force on the body slides down the inclined plane in presence of friction μ is



$$F = mg\sin\theta - f = mg\sin\theta - \mu N = ma$$
$$a = g\sin\theta - \mu g\cos\theta \qquad (\because N = mg\cos\theta)$$

At initial velocity = 0

Let time taken to side the plane t_1

$$t_1 = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2s}{g\sin\theta - \mu g\cos\theta}}$$

In absence of friction let time taken will be –

$$t_2 = \sqrt{\frac{2s}{g\sin\theta}}$$

Given,

$$t_1 = 2t_2$$
$$t_1^2 = 4t_2^2$$
$$\Rightarrow \quad \frac{2s}{g(\sin\theta - \mu\cos\theta)} = \frac{4\times2s}{g\sin\theta}$$

@apna_pdf

$\sin\theta = 4\sin\theta - 4\mu\cos\theta$

$-3\sin\theta = 4\mu\cos\theta$

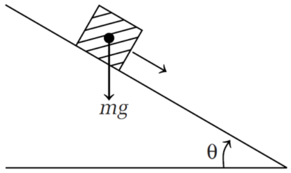
$\mu = \frac{3}{4}\times\tan\theta \qquad [\because \theta = 45°]$

$\mu = \frac{3}{4}\tan 45^\circ \qquad [\because \tan 45^\circ = 1]$

$\mu = \frac{3}{4}$

$\mu = 0.75$

654. A plank with a box on it at one end is gradually raised about the other end. As the angle of inclination with the horizontal reaches 30°, the box starts to slip and slides 4m down the plank in 4s. The coefficients of static and kinetic friction between the box and the plank will be, respectively



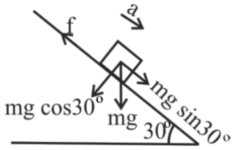
(a) 0.6 and 0.6 (b) 0.6 and 0.5
(c) 0.5 and 0.6 (d) 0.4 and 0.3

AIPMT- 2015

Ans. (d) : Given,

Distance (s) = 4.0 m, time (t) = 4.0 sec and $\theta = 30^\circ$

$\therefore$ Static friction $\mu_s = \tan 30^\circ = 0.577 \approx 0.6$



So, for kinetic friction,

$F = mg\sin 30^\circ - f$

$ma = mg\sin30^\circ - f = mg\sin30^\circ - \mu_k\, mg\cos30^\circ$

$a = g\sin30^\circ - \mu_k\, g\cos30^\circ \qquad .....(i)$

By equation of motion

$s = ut + \frac{1}{2}at^2$

$\Rightarrow \quad 4 = 0 + \frac{1}{2}a(4)^2$

Or $\quad a = 0.5\ m/s^2$

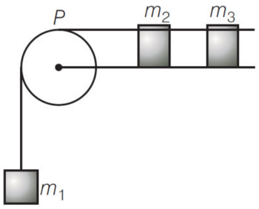
From (i), we get –

$0.5 = 10\times\frac{1}{2} - \mu_k(10)\times\frac{\sqrt{3}}{2}$

Or $\quad \mu_k = \frac{4.5}{5\sqrt{3}} = \frac{4.5}{8.66}$

$\mu_k = 0.519 \approx 0.5$

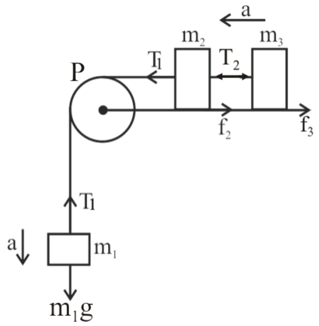
655. A system consists of three masses m_1, m_2 and m_3 connected by a string passing over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is (Assume, $m_1 = m_2 = m_3 = m$)



(a) $\frac{g(1-g\mu)}{9}$ (b) $\frac{2g\mu}{3}$
(c) $\frac{g(1-2\mu)}{3}$ (d) $\frac{g(1-2\mu)}{2}$

AIPMT- 2014

Ans. (c) : Given, three masses m_1, m_2 and m_3 are connected by string shown by below figure.



Coefficient of friction = μ and $m_1 = m_2 = m_3 = m$

Let,

Tension in the string attached to mass m_1 is T_1

Tension in the string attached to mass m_3 is T_2

Using Newton's second law, we get,

$\Rightarrow \quad m_1g - T_1 = m_1a \qquad ....(i)$

$T_1 - f_2 - T_2 = m_2a \qquad ....(ii)$

$T_2 - f_3 = m_3 a \qquad .....(iii)$

By adding above equation (i), (ii) and (iii) we get–

$\Rightarrow \quad m_1g - f_2 - f_3 = (m_1 + m_2 + m_3)a$

Given, $\quad m_1 = m_2 = m_3 = m$

and $\quad f_2 = f_3 = \mu mg$

On putting in above equation, we get –

$\Rightarrow \quad mg - 2\mu mg = 3ma$

$mg(1-2\mu) = 3ma$

$a = \frac{(1-2\mu)g}{3}$

656. A body takes $1\frac{1}{3}$ times as much time to slide down a rough inclined plane as it takes to slide down an identical but smooth inclined plane. If the angle of inclined plane is 45°, the coefficient of friction is

(a) $\frac{7}{16}$ (b) $\frac{9}{16}$
(c) $\frac{7}{9}$ (d) $\frac{3}{4}$

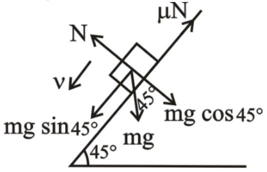
AP EAMCET-1999

@apna_pdf

Ans. (a) : Let body slides the smooth plane in time 't' and the rough plane in $1\frac{1}{3}$t.

Acceleration (a) in smooth incline plane at θ angle

$a = g\sin\theta$



From free body diagram,

Acceleration (a) in smooth incline rough plane at θ angle

$a = g(\sin\theta - \mu g\cos\theta)$

i.e., without friction, $a = g\sin\theta$

and with friction, $a = g(\sin\theta - \mu\cos\theta)$

$\because$ Distance $(s) = ut + \frac{1}{2}at^2$

$$s = \frac{1}{2}at^2 \qquad (u = 0)$$

$\because$ Distance covered in both the cases are same without and with friction,

$$\frac{1}{2}\times g\sin 45°\times t^2 = \frac{1}{2}(g\sin 45° - \mu g\cos 45°)t_2^2$$

$$\Rightarrow \frac{g}{\sqrt{2}}t^2 = \left(\frac{g}{\sqrt{2}} - \frac{\mu g}{\sqrt{2}}\right)\frac{16}{9}t^2 \quad \left(\because t_2 = \frac{4}{3}t\right)$$

$9 = (1 - \mu)\,16$

$\mu = 7/16$

Hence, coefficient of friction, $\mu = 7/16$

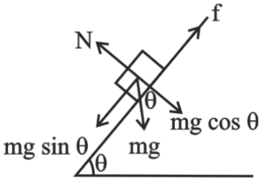
657. A body is sliding down an inclined plane having coefficient of friction 0.5. If the normal reaction is twice that of the resultant downward force along the inclination the angle between the inclined plane and the horizontal is

(a) 15° (b) 30°
(c) 45° (d) 60°

AP EAMCET-2000,2002

Ans. (c) : Given, $\mu = 0.5$, $N = 2f$ (downward)

Let, the angle be θ



$\because \quad N = mg\cos\theta$

$f_{net} = mg\sin\theta - f$

$f_{net} = mg\sin\theta - \mu\, mg\cos\theta \quad (\because f = \mu N)$

According to the question, $N = 2f_{net}$

$mg\cos\theta = 2(mg\sin\theta - \mu\, mg\cos\theta)$

$mg\cos\theta = 2mg(\sin\theta - \mu\cos\theta)$

$(1+2\mu)\cos\theta = 2\sin\theta \quad (\therefore \mu = 0.5)$

$\tan\theta = 2/2 = 1$

$\tan\theta = 45°$

$\theta = 45°$

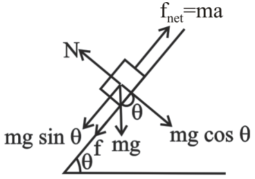
658. A particle is projected up along a rough inclined plane of inclination 45° with the horizontal. If the coefficient of friction is 0.5, the acceleration is

(a) $\frac{g}{2}$ (b) $\frac{g}{2\sqrt{2}}$
(c) $\frac{3g}{2\sqrt{2}}$ (d) $\frac{g}{\sqrt{2}}$

EAMCET-2001

Ans. (c) : Given that, $\theta = 45°$, $\mu = 0.5$

According to the question, the free body diagram:-



Now, $\quad N = mg\cos\theta$

$f_{net} = mg\sin\theta + f$

$ma = mg\sin\theta + \mu\, mg\cos\theta \quad (\because f = \mu N)$

$ma = mg(\sin\theta + \mu\cos\theta)$

Therefore, $a = \dfrac{mg(\sin\theta + \mu\cos\theta)}{m}$

$a = g(\sin 45° + 0.5\cos 45°)$

$$a = g\left(\frac{1}{\sqrt{2}} + \frac{0.5}{\sqrt{2}}\right) = \frac{3g}{2\sqrt{2}}$$

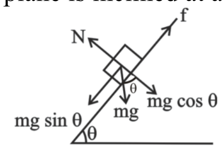
659. A body is sliding down a rough inclined plane. The coefficient of friction between the body and the plane is 0.5. The ratio of the net force required for the body to slide down and the normal reaction on the body is 1 : 2. Then, the angle of the inclined plane is

(a) 15° (b) 30° (c) 45° (d) 60°

EAMCET-2002

Ans. (c) : Given, $\mu = 0.5$, $\frac{f_{net}}{N} = \frac{1}{2}$

Let the plane is inclined at angle θ



$f_{net} = mg\sin\theta - f$

$f = \mu N$ and $N = mg\cos\theta$.

$\therefore F_{net} = mg\sin\theta - \mu mg\cos\theta$

$$\therefore \frac{f_{net}}{N} = \frac{mg\sin\theta - \mu\, mg\cos\theta}{mg\cos\theta} = \frac{1}{2}$$

$\tan\theta - \mu = \frac{1}{2}$

$\tan\theta - 0.5 = \frac{1}{2}$

$\tan\theta = 1 = \tan 45°$

$\boxed{\theta = 45°}$

@apna_pdf

660. When the angle of inclination of an inclined plane is θ, an object slides down with uniform velocity. If the same object is pushed up with a initial velocity u on the same inclined plane; it goes up the plane and stops at a certain distance on the plane. Thereafter the body

(a) slides down the inclined plane and reaches the ground with velocity u.
(b) slides down the inclined plane and reaches the ground with velocity less than u.
(c) slides down the inclined plane and reaches the ground with velocity greater than u.
(d) stays at rest on the inclined plane and will not slide down.

EAMCET-2006

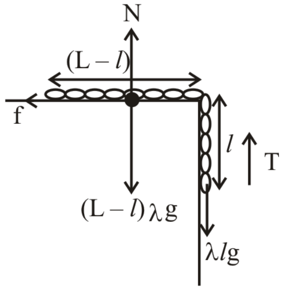
Ans. (d) : In the given situation the body there after stays at rest on the inclined plane and will not slide down.

661. A uniform chain of length L hangs partially from table and held in equilibrium by friction. If greatest length of chain that hangs without slipping is l then the coefficient of friction between chain and table is

(a) $\frac{l}{2}$ (b) $\frac{l}{L+l}$
(c) $\frac{l}{L-l}$ (d) $\frac{l}{L+1}$

EAMCET-1995

Ans. (c) :



Let, mass of chain = m kg

Per unit mass = λ kg/m

So, mass of hanging part = λl kg

mass of upper part of chain = λ (L–l) kg

For hanging part,

$$T = \lambda l g$$

For part on table,

$$N = (L - l)g\lambda$$
$$T = f \Rightarrow T = \mu(L - l)g\lambda$$
$$lg\lambda = \mu(L - l)g\lambda$$
$$\mu = \frac{l}{L - l}$$

662. A body of weight 50 N is placed on a smooth surface. If the force required to move the body on the rough surface is 30 N the coefficient of friction is

(a) 0.6 (b) 1.2
(c) 0.3 (d) 1.67

EAMCET-1996

Ans. (a): Given,

Weight of body (w) = 50N

Force (F) = 30N

$$\text{Coefficient of friction } (\mu) = \frac{F}{N} \quad [\because N = w]$$
$$\mu = \frac{30}{50}$$
$$\mu = 0.6$$

663. A body of mass 10 kg lies on a rough horizontal surface. When a horizontal force F Newton acts on it, it gets an acceleration of 5 ms^{-2} and when the horizontal force is doubled, it gets an acceleration of 18 ms^{-2}. Then, the coefficient of friction between the body and the horizontal surface is (assume g = 10 ms^{-2})

(a) 0.2 (b) 0.8
(c) 0.4 (d) 0.6

EAMCET-1997

Ans. (b): Mass (m) = 10 kg

Friction force (f) = μ.mg

When force is F Newton is acts,

$$\text{acceleration (a)} = \frac{F - f}{m} = 5 \text{ m/s}^2$$
$$F - f = 50N \quad \text{....(i)}$$

When force is 2F is act,

$$\text{Then, acceleration (a)} = \frac{2F - f}{m} = 18 \text{ m/s}^2$$
$$2F - f = 180N \quad \text{.... (ii)}$$

From equation (i) and (ii), we get

$$F = 130N$$

Put this value in equation (i), we get

$$f = 80N$$
$$\mu N = 80 \Rightarrow \mu = \frac{80}{N} = \frac{80}{mg} = \frac{80}{10 \times 10} = 0.8$$

664. An iron block of sides 50 cm × 8 cm × 15 cm has to be pushed along the floor. The force required will be minimum when the surface in contact with ground is

(a) 8 cm × 15 cm surface
(b) 5 cm × 15 cm surface
(c) 8 cm × 5 cm surface
(d) Force is same for all surfaces

EAMCET-1998

Ans. (d): Friction force is independent of the area of contact between the bodies surfaces. So the friction will be same for different areas in contact, its depend on roughness of surface of contact.

The force (F) required to push the iron block should be more than static friction $f_s = \mu_s N$

$$F > f_s$$

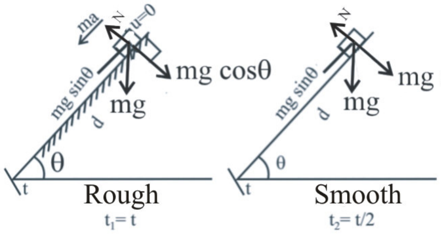
665. To determine the coefficient of friction between a rough surface and a block, the surface is kept inclined at 45° and the block is released from rest. The block takes a time t in moving a distance d. The rough surface is then replaced by a smooth surface and the same experiment is repeated. The block now takes a time t/2 in moving down the same distance d. The coefficient of friction is

@apna_pdf

(a) 3/4 (b) 5/4
(c) 1/2 (d) $1/\sqrt{2}$

EAMCET-2008

Ans. (a) : Given, θ = 45°
Time takes moving distance 'd' on rough surface = t
Time takes moving distance 'd' on smooth surface = t/2



Case (I) when plane is rough,

$$N = mg\cos\theta$$
$$f_s = \mu N$$
$$f_s = \mu\, mg\cos\theta$$
$$mg\sin\theta - f_s = ma$$
$$mg\sin\theta - \mu mg\cos\theta = ma$$
$$a = g\sin\theta - \mu g\cos\theta$$
$$\therefore \quad s = ut + \frac{1}{2}at^2 \qquad \text{(where, } u = 0)$$
$$d = 0\times t_1 + \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t_1^2$$
$$\sqrt{\frac{2d}{g\sin\theta - \mu g\cos\theta}} = t_1$$

Case (II), When $t_2 = t/2$

$$s = ut + \frac{1}{2}at^2$$

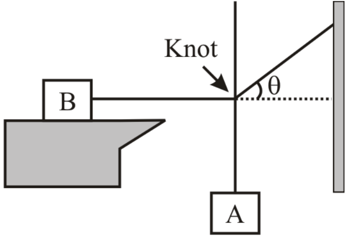
where, u = 0, s = –d
a = – gsinθ (plane is smooth)

$$\therefore \quad d = \frac{1}{2}g\sin\theta t_2^2$$
$$\frac{2d}{g\sin\theta} = t_2^2$$
$$t_2 = \sqrt{\frac{2d}{g\sin\theta}}$$

Given

$$\frac{t_1}{2} = t_2$$
$$\frac{1}{2}\sqrt{\frac{2d}{g\sin\theta - \mu g\cos\theta}} = \sqrt{\frac{2d}{g\sin\theta}}$$
$$\frac{1}{4}\times\frac{2d}{g\sin\theta - \mu g\cos\theta} = \frac{2d}{g\sin\theta}$$
$$\frac{1}{4\sin\theta - 4\mu\cos\theta} = \frac{1}{\sin\theta}$$
$$4\sin\theta - 4\mu\cos\theta = \sin\theta$$
$$3\sin\theta = 4\mu\cos\theta$$
$$\frac{3}{4}\tan\theta = \mu$$
$$\mu = \frac{3}{4}\tan 45^\circ \qquad (\because \theta = 45^\circ)$$
$$\therefore \quad \mu = 3/4$$

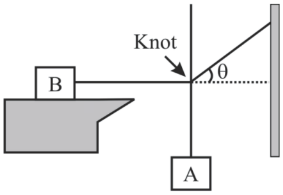
666. Block B lying on a table weighs W. The coefficient of static friction between the block and the table is μ. Assume that the cord between B and the knot is horizontal. The maximum weight of the block A for which the system will be stationary is



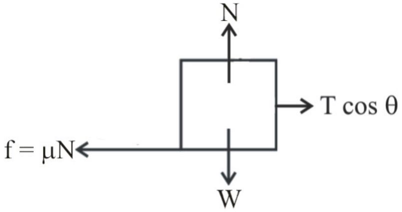
(a) $\frac{W\tan\theta}{\mu}$ (b) μW tanθ
(c) $\mu W\sqrt{1+\tan^2\theta}$ (d) μW sinθ

WB JEE 2015

Ans. (b) : Given,
weight of block B = W



Assume, weight of A is W'.
F.B.D for equilibrium of the system



T cos θ = μN = μW …(i)
T sin θ = W' …(ii)
[Where T = tension between knot and support]
Now, eq.(ii) ÷ eq.(i), we get-

$$\frac{T\sin\theta}{T\cos\theta} = \frac{W'}{\mu W}$$
$$\Rightarrow \quad \tan\theta = \frac{W'}{\mu W}$$
$$\Rightarrow \quad W' = \mu W\tan\theta$$

Hence, the maximum weight of block A(W') = μWtanθ

667. A box of mass 2 kg is placed on the roof of a car. The box would remain stationary until the car attains a maximum acceleration. Coefficient of static friction between the box and the roof of the car is 0.2 and g = 10 ms^{-2}.

@apna_pdf

The maximum acceleration of the car, for the box to remain stationary, is

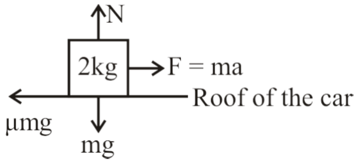
(a) 8 ms^{-2} (b) 6 ms^{-2}

(c) 4 ms^{-2} (d) 2 ms^{-2}

WB JEE 2012

Ans. (d) : Given,

Mass of box (m) = 2 kg



Coefficient of static friction (μ) = 0.2

Here, $\sum F_x = 0$

For box remain in stationary

Applied force = friction force

$F = f_r$

$ma = \mu.N$

$ma = \mu.mg$

$\Rightarrow \quad a = \mu g$

$\Rightarrow \quad a = 0.2 \times 10$

$\Rightarrow \quad a = 2 m/sec^2$

Hence, maximum acceleration (a) = 2 m/s^2 for the box remain in stationary

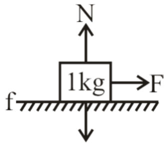
668. Force required to move a mass of 1 kg at rest on a horizontal rough plane (μ = 0.1 and g = 9.8 m/s^2) is

(a) 0.98 N (b) 0.49 N

(c) 9.8 N (d) 4.9 N

WB JEE 2008

Ans. (a) :



Given, m = 1kg, μ = 0.1

According to question –

Applied force = friction force,

$F = f_r$

$F = \mu.N$

$F = \mu.mg$

$F = 0.1 \times 1 \times 9.8$

$F = 0.98$ N

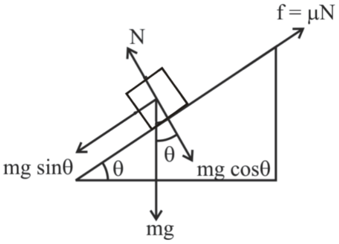
669. A block kept on a rough surface starts sliding when the inclination of the surface is θ with respect to the horizontal. The coefficient of static friction between the block and the surface is :

(a) sec θ (b) sin θ

(c) tan θ (d) cos θ

Karnataka CET-2012

Ans. (c) : As the block starts slipping for angle of inclination θ, it must be equal to angle of repose given by



According to figure –

$N = mg\cos\theta$ ....(i)

and, $f = \mu N = mg\sin\theta$ ....(ii)

From equation (i) and (ii)

$$\frac{\mu N}{N} = \frac{mg\sin\theta}{mg\cos\theta}$$

$\mu_s = \tan\theta$

670. If coefficient of static friction is μ_s and coefficient of kinetic friction is μ_k, which is correct?

(a) $\mu_s = \mu_k$ (b) $\mu_s > \mu_k$

(c) $\mu_s < \mu_k$ (d) Cannot predict

UP CPMT-2007

Ans. (b) : The coefficient of static friction is large because body initially in rest position is harder to start rather than body already in motion.

So, the correct answer is $\mu_s > \mu_k$.

671. The coefficient of friction between the tyres and the road is 0.25. The maximum speed with which car can be driven round a curve of radius 40 m without skidding is (assume g = 10 ms^{-2})

(a) 40 ms^{-1} (b) 20 ms^{-1}

(c) 15 ms^{-1} (d) 10 ms^{-1}

UP CPMT-2007

Ans. (d) : For driving around a curve (centripetal) force is provided by friction, so

$$\frac{mV^2}{r} < f$$

$$\frac{mV^2}{r} < \mu mg$$

So, $V < \sqrt{\mu gr}$

$V_{max} = \sqrt{\mu gr}$

Substituting, μ = 0.25, r = 40 m, g = 10 ms^{-2} we get

$V_{max} = \sqrt{0.25 \times 10 \times 40}$

$V_{max} = \sqrt{100}$

$V_{max} = 10 ms^{-1}$

672. A block rests on a rough horizontal surface, μ is the coefficient of friction between the block and the surface. A force mg pulls the block. This force acts an angle θ with the vertical side of the block. The mass of the block is m. The block can be pulled along the surface, if $\cot\frac{\theta}{2}$

@apna_pdf

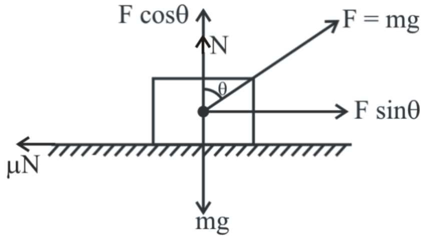
(a) $> \mu$ (b) $= \mu$

(c) $< \mu$ (d) $\frac{\mu}{6}$

UP CPMT-2014

AP EAMCET - 2005

Ans. (a) :



Normal reaction (N) = (mg – F cosθ)

To pull the block along the surface

$$F \sin\theta \geq \mu N$$
$$F \sin\theta \geq \mu(mg - F\cos\theta)$$
$$mg \sin\theta \geq \mu\, mg\, [1 - \cos\theta]$$
$$\sin\theta \geq \mu\, [1 - \cos\theta]$$
$$2\sin\frac{\theta}{2}\cos\frac{\theta}{2} \geq \mu \times 2\sin^2\frac{\theta}{2}$$
$$\cos\frac{\theta}{2} \geq \mu \times \sin\frac{\theta}{2}$$
$$\cot\frac{\theta}{2} \geq \mu$$

673. An army vehicle of mass 1000 kg is moving with velocity of 10 m/s and is acted upon by a forward force of 1000 N due to the engine and a retarding force of 500 N due to the friction. What will be its velocity after 10s?

(a) 5 m/s (b) 10 m/s

(c) 15 m/s (d) 20 m/s

UP CPMT-2010

Ans. (c) : Given $m = 1000\text{kg}$, $u = 10$ m/s, $t = 10$s

Applied force (F) = 1000 N

Retarding force (f) = 500N

We know that,

$$F_{net} = ma$$
$$F - f = ma$$
$$a = \frac{F - f}{m} = \frac{1000 - 500}{1000}$$
$$a = \frac{500}{1000} = 0.5 \text{ m/s}^2$$

Again, $v = u + at$

$$= 10 + 0.5 \times 10$$
$$= 15 \text{m/s}$$

∴ Final velocity after 10 s will be 15 m/s

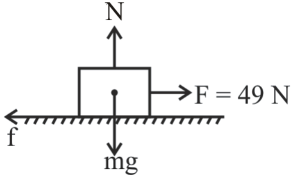
674. A force of 49 N is just able to move a block of wood weighing 10 kg on a rough horizontal surface. Its coefficient of friction is

(a) 1 (b) 0.7

(c) 0.5 (d) zero

UP CPMT-2005

Ans. (c) : Given, F = 49 N, m = 10 kg, g = 10 m/s^2



The moment of block is just to move -

Applied force = friction force

$$F = f = \mu N$$
$$\mu = \frac{F}{N} = \frac{F}{mg} \qquad (\because N = mg)$$
$$= \frac{49}{10 \times 10} = 0.49 \approx 0.5$$

675. A car is moving at a speed of 60 km/h traversing a circular road track of radius 60 m. The minimum coefficient of friction to prevent the skidding of the car is (g = 10 m/s^2)

(a) 25/54 (b) 21/54

(c) 15/44 (d) 21/44

TS EAMCET(Medical)-2015

Ans. (a) : Given,

v = 60 km/ hr = $60 \times \frac{5}{18}$ m/s = 50/3 m/s, r = 60 m,

g = 10 m/s^2

The only force that can create centripetal acceleration while the car is moving on a flat, circular track and prevent it from, skidding is frictional force

Since, Centripetal force = friction force

$$\frac{mv^2}{r} = \mu mg$$
$$\mu = \frac{v^2}{rg}$$
$$\mu = \frac{(50/3)^2}{60 \times 10}$$
$$\mu = 25/54$$

676. Assuming that the coefficient of friction between the road and the tyre of a car is 0.4, the maximum speed of the car on a turn of radius 100 m on a level road will be:

(a) 10 m/s (b) 20 m/s

(c) 30 m/s (d) 40 m/s

MP PET -2013

Ans. (b) : Given, r = 100 m, μ = 0.4, g = 10 m/s^2

We know that,

Frictional force = Centripetal force

$$\mu m g = \frac{mv^2}{r}$$
$$v^2 = \mu r g$$
$$v = \sqrt{\mu r g}$$
$$v = \sqrt{0.4 \times 100 \times 10}$$
$$\boxed{v = 20 \text{m/s}}$$

@apna_pdf

677. A motor car is moving on a straight horizontal road with a speed of 20 m/s. The coefficient of friction between the tyres and the road is 0.4. The minimum distance in which the car can come to stop is:

(a) 50 m (b) 125 m
(c) 100 m (d) 150 m

MP PET -2009, 2013

Ans. (a) : Given, Initial velocity (u) = 20 m/s

Final velocity (v) = 0

Coefficient of friction (μ) = 0.4

So, Maximum retardation force = μ N

$$ma = \mu mg$$
$$a = \mu.g$$

Using third equation of motion-

$$v^2 = u^2 - 2as$$
$$s = \frac{u^2}{2a} \qquad (v = 0)$$
$$s = \frac{u^2}{2\mu g}$$
$$s = \frac{20\times20}{2\times0.4\times10}$$
$$s = 50\text{ m}$$

678. A car of mass 1000 kg moves on a circular track of radius 40 m. If the coefficient of friction is 1.28. The maximum velocity with which the car can be moved, is

(a) 22.4 m/s (b) 112 m/s
(c) $\frac{0.64\times40}{1000\times100}$ m/s (d) 1000 m/s

JIPMER-2013, 2003

Ans. (a) : Given,

Mass of car (m) = 1000 kg

Radius of track (r) = 40m

μ = 1.28

g = 10 m/s^2

We know that,

$$v = \sqrt{\mu gr}$$
$$v = \sqrt{1.28\times10\times40}$$
$$v = \sqrt{512}$$
$$v \approx 22.4\text{ m/s}$$

679. A stone weighing 1 kg and sliding on ice with a velocity of 2m/s is stopped by friction in 10 s. The force of friction (assuming it to be constant) will be

(a) – 20 N (b) –0.2N
(c) 0.2N (d) 20 N

JIPMER-2012

Ans. (b) : Given,

initial velocity (u) = 2m/sec

m = 1 kg

velocity (v) = 0

time (t) = 10 sec

Using first equation of motion,

$$v = u + at$$
$$a = \frac{v-u}{t} = \frac{0-2}{10}$$
$$a = -\frac{2}{10} = -\frac{1}{5}$$

∵ Force (F) = mass (m) × acceleration (a)

$$F = 1\times-\frac{1}{5}$$
$$F = -0.2\text{ N}$$

680. A box of mass 10 kg is placed near the rear end of a long flat trolley such that it is 2 m from the rear end of the trolley. The coefficient of friction between the box and the trolley surface is 0.2, starting from rest, the trolley is given a uniform acceleration of 3 m/s^2 . How much distance the trolley will cover by the time the box fall off from the trolley (g = 10 m/s^2)?

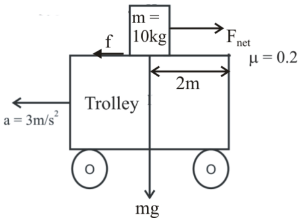
(a) 2 m (b) 4 m
(c) 6 m (d) 8 m

Assam CEE-2016

Ans. (c) : Mass of box m = 10 kg

μ = 0.2

a = 3 m/s^2, g = 10 m/s^2



∴ Force on the box

$$F = ma = 10\times3 = 30\text{ N}$$

Friction force $f = \mu\, mg = 0.2\times10\times10$
$= 20$ N

∴ Net force on box toward right is–

$$F_{net} = F - f = 30 - 20 = 10\text{ N}$$

Since due to friction box will face an acceleration towards rear end there fare,

$$a_{net} = \frac{F_{net}}{m} = \frac{10}{10} = 1\text{m/s}^2$$

We have,

s = 2m, u = 0 m/s, a = 1 m/s^2

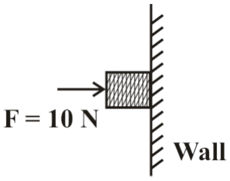
$$s = ut + \frac{1}{2}at^2$$
$$\therefore\ 2 = 0 + \frac{1}{2}\times1\times t^2$$
$$t^2 = 4$$
$$\therefore\ \boxed{t = 2\,\text{sec}}$$

Now, the distance travelled by the trolley in 2 sec

$$s = ut + \frac{1}{2}at^2$$
$$s = 0 + \frac{1}{2}\times3\times2^2 = 6\text{ m}$$

@apna_pdf

681. A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between block and wall is 0.2. The weight of the block is



(a) 20 N (b) 50 N
(c) 100 N (d) 2 N

Assam CEE-2014

Ans. (d) : Given, horizontal force (F) =10N, coefficient of friction between block and wall (μ) = 0.2
Therefore, friction force (f) = 0.2×10 = 2 N
Since, the block is in rest
Then, Weight of block = friction force
$= \mu N = 0.2\times10 = 2$ N

682. A body is moving along a rough horizontal surface with an initial velocity of 10 ms^{-1}. If the body comes to rest after travelling a distance of 12 m, then the coefficient of sliding friction will be

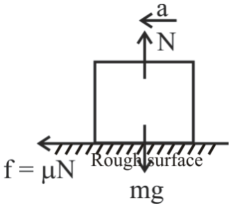
(a) 0.5 (b) 0.2
(c) 0.4 (d) 0.6

JIPMER-2016

Ans. (c) : Given that,
Initial velocity (u) = 10 m/sec
s = 12 m
We know that,

$$v^2 = u^2 - 2as$$
$$0 = (10)^2 - 2 \times a \times 12$$
$$a = 4.17 \text{ m/sec}^2$$

For coefficient of sliding friction



From the figure, $\sum F_y = 0$

$$N = mg \quad \text{……(i)}$$

And $\sum F_x = 0$

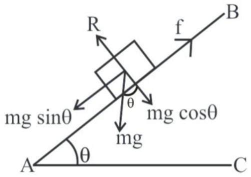
$$ma = f = \mu N$$
$$ma = \mu mg \quad \text{from equation (i)}$$
$$\mu = \frac{ma}{mg}$$
$$\mu = \frac{a}{g} = \frac{4.17}{10} = 0.41$$

683. A body at rest slides down a 30° inclined plane. The time taken by it to slide down is twice the time it takes when it slides down the same distance in the absence of friction. The coefficient of friction between the body and the inclined plane is

(a) 0.43 (b) 0.37
(c) 0.64 (d) 0.75

JIPMER-2016

Ans. (a) : Given, $\theta = 30^o$



From the figure

$$R = mg\cos\theta \text{ ….. (i)}$$

Net force on the body when slides down on inclined plane

$$F = mg\sin\theta - f \text{ ...... (ii)}$$

And, $F = ma$

Then, $ma = mg\sin\theta - \mu R \ [\because f = \mu R]$

$\therefore \quad ma = mg\sin\theta - \mu mg\cos\theta \quad [\because R = mg\cos\theta]$

$$ma = mg(\sin\theta - \mu\cos\theta)$$
$$a = g(\sin\theta - \mu\cos\theta)$$

Time taken by the body to slide down the plane

$$t_1 = \sqrt{\frac{2S}{a}} = \sqrt{\frac{2S}{g\sin\theta - \mu g\cos\theta}}$$

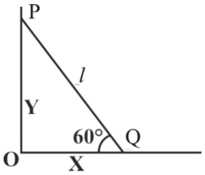
And time taken by the body in the absence of friction

$$t_2 = \sqrt{\frac{2S}{g\sin\theta}}$$

Given, $t_1 = 2t_2$

$$\sqrt{\frac{2S}{g(\sin\theta - \mu\cos\theta)}} = 2\sqrt{\frac{2S}{g\sin\theta}}$$
$$\frac{2S}{g(\sin\theta - \mu\cos\theta)} = 4\times\frac{2S}{g\sin\theta}$$
$$\sin\theta = 4\sin\theta - 4\mu\cos\theta$$
$$3\sin\theta = 4\mu\cos\theta$$
$$3\tan\theta = 4\mu$$
$$\mu = \frac{3}{4}\tan\theta = \frac{3}{4}\tan 30° = 0.43$$

684. A rod PQ of length *l* is moving with ends remaining in contact with frictionless wall and floor. If at the instant, shown the velocity of end Q is 2 m/s towards negative direction of x. The speed of end P will be

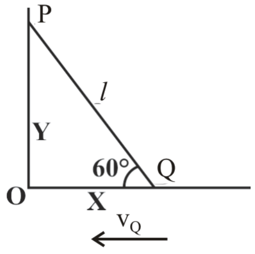


(a) $\sqrt{3}\,ms^{-1}$ (b) $\frac{2}{\sqrt{3}}ms^{-1}$
(c) $\sqrt{2}\,ms^{-1}$ (d) $\frac{\sqrt{5}}{2}ms^{-1}$

JIPMER-2015

@apna_pdf

Ans. (b) :



Given that velocity at Q

$v_Q = -2$m/sec

Δ POQ

$X^2 + Y^2 = l^2$ …..(i)

On differentiating equation (i) w.r to t

$$2X\frac{dX}{dt} + 2Y\frac{dY}{dt} = 0$$

From the figure

$$X = l\cos 60^\circ = \frac{l}{2} \text{ and } Y = l\sin 60^\circ = \frac{\sqrt{3}l}{2}$$

$$2\times\left(\frac{l}{2}\right)\times(-2) + 2\times\left(\frac{\sqrt{3}l}{2}\right)\frac{dY}{dt} = 0$$

$$-2 + \left(\sqrt{3}\right)\frac{dY}{dt} = 0$$

$$-2 = -\frac{\sqrt{3}dY}{dt}$$

$$\frac{dY}{dt} = v_P = \frac{2}{\sqrt{3}}\text{m/sec}$$

Hence, the speed of end P will be $v_p = \frac{2}{\sqrt{3}}$ m/sec.

685. A block slides down on an incline of angle 30° with acceleration $\frac{g}{4}$. Find the kinetic friction coefficient.

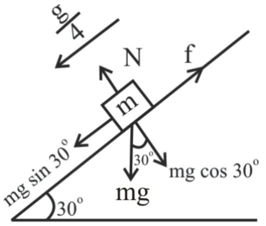
(a) $\frac{1}{2\sqrt{2}}$ (b) 0.6

(c) $\frac{1}{2\sqrt{3}}$ (d) $\frac{1}{\sqrt{2}}$

JIPMER-2015

Ans. (c) : Given, $a = \frac{g}{4}$, $\theta = 30^\circ$

Let block has mass m and μ is kinetic friction.



from the figure

$N = mg\cos 30^\circ$

We know

$f = \mu N$

$f = \mu mg\cos 30^\circ$ ……(i)

And $mg\sin 30^\circ - f = ma$ ……(ii)

$mg\sin 30^\circ - \mu mg\cos 30^\circ = m.g/4$ [from eq^n (i)]

$$\sin 30^\circ - \mu\cos 30^\circ = \frac{1}{4}$$

$$\sin 30^\circ - \mu\cos 30^\circ = \frac{1}{4}$$

$$\frac{1}{2} - \frac{\sqrt{3}}{2}\mu = \frac{1}{4}$$

$$\frac{1}{2} - \frac{1}{4} = \frac{\sqrt{3}}{2}\mu$$

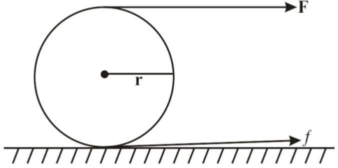
$$\frac{2-1}{4} = \frac{\sqrt{3}}{2}\mu$$

$$\frac{1}{4} = \frac{\sqrt{3}}{2}\mu$$

$$\mu = \frac{1}{2\sqrt{3}}$$

$$\boxed{\mu = \frac{1}{2\sqrt{3}}}$$

686. A tangential force acting on the top of sphere of mass m kept on a rough horizontal place as shown in figure



If the sphere rolls without slipping, then the acceleration with which the centre of sphere moves, is

(a) $\frac{10F}{7m}$ (b) $\frac{F}{2m}$

(c) $\frac{3F}{3m}$ (d) $\frac{7F}{2m}$

JIPMER-2015

Ans. (a) : Let a is the acceleration of the centre of sphere.

Then,

$$\text{Angular acceleration } (\alpha) = \frac{a}{r}$$

We know,

For linear motion of the centre

$f + F = ma$ ……(i)

And for rotational motion about the centre.

We know

Torque (τ) = Iα

Then,

$Fr - fr = I\alpha$

$$Fr - fr = \left(\frac{2}{5}mr^2\right)\left(\frac{a}{r}\right)$$

[moment of Inertia of solid sphere (I) $= \frac{2}{5}mr^2$]

@apna_pdf

$$F - f = = \frac{2}{5} ma \qquad \ldots\ldots(ii)$$

From equation (i) and (ii)

$$2F = \frac{7}{5} ma$$

$$a = \frac{10F}{7m}$$

687. A bullet of mass of 0.02 kg travelling horizontally with velocity 250 ms^{-1} strikes a block of wood of mass 0.23 kg which rests on a rough horizontal surface. After the impact, the block and bullet move together and come to rest after travelling a distance of 40 m. The coefficient of sliding friction of the rough surface is ($g = 9.8\ ms^{-2}$)

(a) 0.75　　(b) 0.61
(c) 0.51　　(d) 0.30

AP EAMCET -2009
BITSAT-2009

Ans. (c) : Given that, $m_1 = 0.02$ kg, $m_2 = 0.23$ kg, $u_1 = 250$ m/s, $u_2 = 0$ m/s, distance (d) = 40 m

According to conservation of momentum–

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$0.02 \times 250 + 0.23 \times 0 = 0.02v + 0.23v$$

$$5 + 0 = v\,(0.25)$$

$$v = \frac{5}{0.25}$$

$$v = 20\ m/s$$

Now, by conservation of energy

$$\frac{1}{2}mv^2 = \mu R.d$$

$$\frac{1}{2}mv^2 = \mu mg.d \qquad \{\because R = mg\}$$

$$\frac{1}{2}v^2 = \mu gd$$

$$\frac{1}{2} \times 20^2 = \mu \times 9.8 \times 40$$

$$\mu = \frac{20^2/2}{9.8 \times 40} = 0.51$$

688. When the engine is switched off a vehicle of mass M is moving on a rough horizontal road with momentum p. If the coefficient of friction between the road and tyres of the vehicle is μ_k, the distance travelled by the vehicle before it comes to rest is

(a) $\frac{p^2}{2\mu_k M^2 g}$　　(b) $\frac{2\mu_k M^2 g}{p^2}$
(c) $\frac{p^2}{2\mu_k g}$　　(d) $\frac{p^2 M^2}{2\mu_k g}$

AP EAMCET -2012

Ans. (a) : We know that, initially kinetic energy with momentum of the engine is–

$$K.E = \frac{p^2}{2M}$$

This KE converts totally into the work done in case of friction until the point the vehicle stop.

Thus, $\frac{p^2}{2M} = \mu_k MgS$

Where, S = Distance travelled before it come to rest

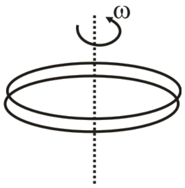
$$\therefore \qquad S = \frac{p^2}{2\mu_k M^2 g}$$

689. A uniform circular disc of radius R, lying on a frictionless horizontal plane is rotating with an angular velocity 'ω' about is its own axis. Another identical circular disc is gently placed on the top of the first disc coaxially. The loss in rotational kinetic energy due to friction between the two discs, as they acquire common angular velocity is (I is moment of inertia of the disc)

(a) $\frac{1}{8}I\omega^2$　　(b) $\frac{1}{4}I\omega^2$
(c) $\frac{1}{2}I\omega^2$　　(d) $I\omega^2$

AP EAMCET -2013

Ans. (b): Let, angular velocity of the system after placing another disc of mass m.



By the of conservation of angular momentum.

$$I\omega = 2I\omega'$$

$$\omega' = \frac{\omega}{2}$$

Therefore, the resultant loss in K.E.

$$\Delta K.E. = \frac{1}{2}I\omega^2 - \frac{1}{2}(2I)\left(\frac{\omega}{2}\right)^2$$

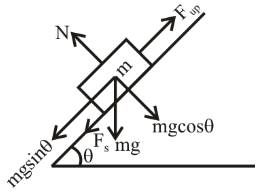
$$= \frac{1}{4}I\omega^2$$

690. The force required to move a body up a rough inclined plane is double the force required to prevent the body from sliding down the plane. The coefficient of friction, when the angle of inclination of the plane is 60^o is

(a) $\frac{1}{3}$　　(b) $\frac{1}{\sqrt{2}}$
(c) $\frac{1}{\sqrt{3}}$　　(d) $\frac{1}{2}$

AP EAMCET -2014

Ans. (c): Given, angle of inclination of the plane is 60°.
Let, the coefficient of friction is μ.



@apna_pdf

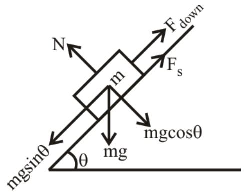
For upward motion, $F_{up} = mg \sin\theta + F_s$

$$F_{up} = mg\sin\theta + \mu\, mg\cos\theta$$

$$F_{up} = mg(\sin 60^o + \mu\cos 60^o)$$

$$F_{up} = mg\left(\frac{\sqrt{3}}{2} + \mu\times\frac{1}{2}\right)$$

$$F_{up} = mg\left(\frac{\sqrt{3}+\mu}{2}\right) \qquad .....(i)$$



For downward motion, $F_{down} = mg\sin\theta - F_s$

$$= mg\sin\theta - \mu mg\cos\theta$$

$$= mg(\sin 60^o - \mu\cos 60^o)$$

$$= mg\left(\frac{\sqrt{3}}{2} - \mu\times\frac{1}{2}\right)$$

$$F_{down} = mg\left(\frac{\sqrt{3}-\mu}{2}\right) \qquad ....(ii)$$

According to question, $F_{up} = 2 \times F_{down}$

$$mg\left(\frac{\sqrt{3}+\mu}{2}\right) = 2\times mg\left(\frac{\sqrt{3}-\mu}{2}\right)$$

$$\sqrt{3}+\mu = 2\sqrt{3}-2\mu$$

$$3\mu = \sqrt{3}$$

$$\mu = \frac{1}{\sqrt{3}}$$

691. A horizontal force just sufficient to move a body of mass 4 kg lying on a rough horizontal surface, is applied on it. Coefficients of static and kinetic frictions are 0.8 and 0.6 respectively. If the force continues to act even after the body has started moving, the acceleration of the body is (take, g = 10 ms^{-2}).

(a) 6 ms^{-2} (b) 8 ms^{-2}

(c) 2 ms^{-2} (d) 4 ms^{-2}

AP EAMCET -2015, 2003

Ans. (c) : Given, mass of body (m) = 4 kg, g = 10 m/s^2, static friction (μ_s) = 0.8, kinetic friction (μ_k) = 0.6

As the body in rest. Then, the force required to move the body (F_1) = $\mu_s$mg.

After the body started motion, the friction will become kinetic friction.

So, the required force to increase the velocity of the body (F_2) = $\mu_k$mg

Thus, $F = F_1 - F_2$

$$F = (\mu_s - \mu_k)\, mg$$

$$F = (0.8 - 0.6) \times 4 \times 10 = 8\text{ N}$$

$$\therefore \quad a = \frac{F}{m} = \frac{8}{4} = 2\,m/s^2$$

692. A particle is place at rest inside a hollow hemisphere of radius R. The coefficient of friction between the particle and the hemisphere is $\mu = \frac{1}{\sqrt{3}}$. The maximum height up to which the particle can remain stationary is

(a) $\frac{R}{2}$ (b) $\left(1-\frac{\sqrt{3}}{2}\right)R$

(c) $\frac{\sqrt{3}}{2}R$ (d) $\frac{3R}{8}$

AP EAMCET -2016

Ans. (b) : Given, radius of hollow hemisphere = R

Coefficient of friction between the particle and hemisphere (μ) = $\frac{1}{\sqrt{3}}$

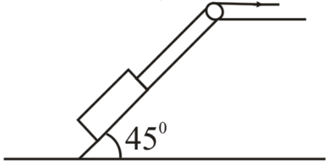
We know that, $h_{max} = \left(1 - \frac{1}{\sqrt{(\mu)^2+1}}\right)R$

$$= \left(1 - \frac{1}{\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2+1}}\right)\times R$$

$$= \left(1 - \frac{1}{\sqrt{1/3+1}}\right)\times R$$

$$h_{max} = \left(1 - \frac{\sqrt{3}}{2}\right)R$$

693. A block of mass 200 kg is being pulled up by men on an inclined plane at angle of 45^o as shown. The coefficient of static friction is 0.5. Each man can only apply a maximum force of 500 N. Calculate the number of men required for the block to just start moving up the plane



(a) 10 (b) 15

(c) 5 (d) 3

AMU-2010

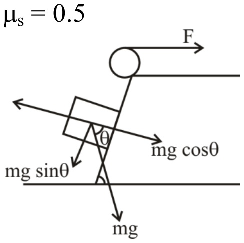
Ans. (c) : Given,

F = 500 N

θ = 45^o

m = 200 kg

μ_s = 0.5



@apna_pdf

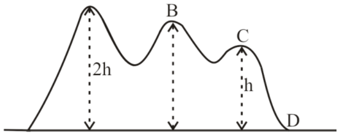
Total force required

$$F = mg\sin\theta + f$$
$$F = mg\sin\theta + \mu_s R$$
$$F = mg\sin\theta + \mu_s\, mg\cos\theta$$
$$F = mg[\sin\theta + \mu_s \cos\theta]$$
$$F = 200 \times 10[\sin45° + 0.5\cos45°]$$
$$F = \frac{200\times10\times3}{2\sqrt{2}}$$

The number of men required will be

$$= \frac{200\times10\times3}{500\times\sqrt{2}\times2} \approx 5$$

694. A small roller coaster starts at point A with a speed u on a curved track as shown in the figure.



The friction between the roller coaster and the track is negligible and it always remains in contact with the track. The speed of roller coaster at point D on the track will be

(a) $(u^2+gh)^{\frac{1}{2}}$ (b) $(u^2+2gh)^{\frac{1}{2}}$

(c) $(u^2+4gh)^{\frac{1}{2}}$ (d) u

AMU-2009

Ans. (c) : Let,

speed = v (roller coaster at point D)

Using the law of conservation of energy between points A and D, we get

$$\frac{1}{2}mu^2 + mg(2h) = \frac{1}{2}mv^2 + 0$$
$$u^2 + 4gh = v^2$$
$$v = \sqrt{u^2+4gh} = (u^2+4gh)^{1/2}$$

695. What can be the maximum speed of a car on a turn of radius 28 m if the coefficient of friction between the tyres and the road is 0.7? (Take g = 10 m/s^2 and assume no slope is given to the road)

(a) 7 m/s (b) 14 m/s
(c) 21 m/s (d) 28 m/s

AMU-2006

Ans. (b) : Given,

Radius (r) = 28 m

Coefficient of friction (μ) = 0.7

$g = 10$ m/s^2

We know that

Speed, $v = \sqrt{\mu rg}$

$$v = \sqrt{0.7\times28\times10}$$
$$v = \sqrt{\frac{7}{10}\times28\times10}$$
$$v = \sqrt{7\times7\times4}$$
$$v = 7\times2$$
$$v = 14 \text{ m/s}$$

696. A 60 kg body is pushed with just enough force to start motion on a floor. If the same force continues to act afterwards, the acceleration of the body is (coefficients of static and sliding friction are 0.5 and 0.4 respectively)

(a) 4.9 m/s^2 (b) 3.92 m/s^2
(c) 0.98 m/s^2 (d) zero

AMU-2003

Ans. (c): Given,

mass (m) = 60 kg

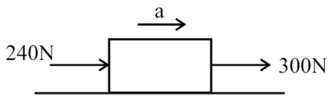
$\mu_s = 0.5$

$\mu_k = 0.4$

Limiting friction $= \mu_s \times N = \mu_s\, mg$
$= 0.5 \times 60 \times 10 = 300$ N

Kinetic friction $= \mu_k \times N = \mu_k\, mg$
$= 0.4 \times 60 \times 10$
$= 240$ N

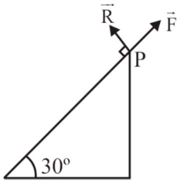
So,



$$F_{net} = ma$$
$$300 - 240 = 60 \times a$$
$$60 = 60 \times a$$

Acceleration a = 1 m/s^2

697. In the following figure, an object of mass 1.2 kg is at rest at point P. If R and F are the reaction and the friction force, respectively, then

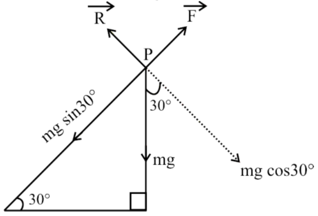


(a) $R = 6N; F = 6\sqrt{3}N$ (b) $R = 3N; F = 3\sqrt{3}N$

(c) $R = 6N; F = 3N$ (d) $R = 6\sqrt{3}N; F = 6N$

AMU-2011

Ans. (d) : Given, m = 1.2 kg



Free body diagram of the given question is as following from the figure we can say that for object to be rested at P. body is in equilibrium,

so $R = mg\cos30°$

and $F = mg\sin30°$

Thus, $R = 1.2\times10\times\frac{\sqrt{3}}{2}$

$$R = 6\sqrt{3}\text{ N}$$
$$F = 1.2\times10\times\frac{1}{2}$$
$$F = 6\text{ N}$$

@apna_pdf

698. A block slides down a curved frictionless surface of height 12 m and then moves up a rough inclined plane of angle of inclination 45^o. If the coefficient of kinetic friction between the block and the inclined plane is 0.2. the maximum height reached by the block is

(a) 12 m (b) 10 m

(c) 8 m (d) 6 m

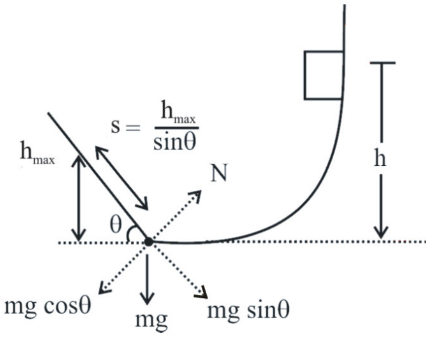
AP EAMCET(Medical)-2016

Ans. (b) : Given,

$h = 12$ m

$\theta = 45°$

$\mu = 0.2$



Friction is only force which is changing mechanical energy of system.

$$w_{friction} = \Delta ME$$

$$\mu_k\ mg\ s\cos\theta = (mg\ h_{max} - mgh)$$

$$\because \quad s = \frac{h_{max}}{\sin\theta}$$

$$\therefore\ mg\ h_{max} = mgh - \mu_k\ mg\ h_{max}\cot\theta$$

by solving

$$h_{max} = \frac{h}{1+\mu_k\cot\theta}$$

$$\text{So, } h_{max} = \frac{12}{1+0.2\cot 45°} = \frac{12}{1+0.2\times 1}$$

$$= \frac{12}{1.2}$$

$$h_{max} = 10\text{m}$$

699. A bullet of mass 50 g moving horizontally with a velocity 210 ms^{-1} gets embedded in a block of mass 1 kg kept on a rough horizontal surface. If the coefficient of kinetic friction between the block and the surface is 0.5, the block-bullet system will move a distance of ________ before coming to rest. (Acceleration due to gravity = 10 ms^{-2})

(a) 40 m (b) 30 m

(c) 20 m (d) 10 m

AP EAMCET(Medical)-2016

Ans. (d) : Conservation of momentum

$$mu = (M+m)v$$

$$v = \frac{mu}{M+m} = \frac{0.05\times 210}{1.05}$$

$$v = 10 \text{ m/s}$$

$$\text{Acceleration } a = -\mu_k g = -0.5\times 10 = -5\,m/s^2$$

by equation of motion,

$$v^2 = u^2 + 2as$$

$$0 = u^2 + 2as$$

$$-u^2 = 2as$$

$$s = \frac{-u^2}{2a}$$

$$s = \frac{-v^2}{2a} = \frac{-(10)^2}{-2\times 5} = \frac{10\times 10}{10} \qquad (\because\ u = v)$$

$$s = 10 \text{ m}$$

700. An inclined plane making an angle 30^o with the horizontal is placed in a uniform horizontal electric field of 100 Vm^{-1}. A particle of mass 1 kg and charge 0.01 C is allowed to slide down from rest from the top of the inclined plane. If the coefficient or friction is 0.2, the particle reaches the bottom of the inclined plane in 1 second. Then the length of the inclined plane is (Acceleration due to gravity = 10 ms^{-2})

(a) 1.245 m (b) 1.323 m

(c) 1.151 m (d) 1.172 m

AP EAMCET(Medical)-2016

Ans. (c) : Given,

$\theta = 30^o$

$E = 100$ V/m

$m = 1$ kg

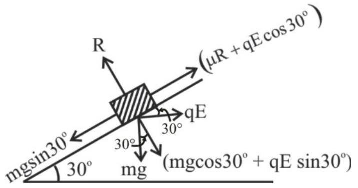
$q = 0.01$ C

$\mu = 0.2$

$t = 1$ second

$g = 10\ m/s^2$

$h = ?$



From figure, $R = mg\cos 30^o + qE\sin 30^o$

$\therefore$ Net force,

$$F = mg\sin 30^o - (\mu R + qE\cos 30^o)$$

$$F = mg\sin 30^o - \mu R - qE\cos 30^o$$

$$F = mg\sin 30^o - \mu\,(mg\cos 30^o + qE\sin 30^o) - qE\cos 30^o$$

$$F = mg\sin 30^o - \mu mg\cos 30^o - \mu qE\sin 30^o - qE\cos 30^o$$

$$F = mg\sin 30^o - \mu mg\cos 30^o - qE(\mu\sin 30^o + \cos 30^o)$$

Divided by m-

$$\frac{F}{m} = \left(g\sin 30^o - \mu g\cos 30^o\right) - \frac{qE}{m}\left(\mu\sin 30^o + \cos 30^o\right)$$

$$a = 10\times\frac{1}{2} - 0.2\times 10\times\frac{\sqrt{3}}{2} - \frac{0.01\times 100}{1}\left(0.2\times\frac{1}{2}+\frac{\sqrt{3}}{2}\right)$$

$$a = 5-\sqrt{3}-\left(0.1+\frac{\sqrt{3}}{2}\right)$$

$$a = \frac{10-2\sqrt{3}-0.2-\sqrt{3}}{2}$$

@apna_pdf

$$a = \frac{10-0.2-3\sqrt{3}}{2}$$

$$a = \frac{10-0.2-5.196}{2} = \frac{4.604}{2}$$

$$a = 2.302$$

So, By equation of motion, for the length of the inclined plane.

$$s = ut + \frac{1}{2}at^2$$

$$s = 0 + \frac{1}{2} \times 2.302 \times 1^2$$

$$s = \frac{2.302}{2} = 1.151\,\text{m}$$

701. A block of ice of mass 50 kg is sliding on a horizontal plane. It starts with speed 5 m/s and stops after moving through some distance. The mass of ice that has melted due to friction between the block and the surface is (Assuming that no energy is lost and latent heat of fusion of ice is 80 cal/g, J = 4.2 J/cal)

(a) 1.86 g (b) 2.86 g
(c) 3.86 g (d) 0.86 g

AP EAMCET(Medical)-2014

Ans. (a) : Given, m = 50 kg, v = 5 m/s, L = 80 Cal/g
J = 4.2 J/Cal

∵ Heat lost i.e. Q_1 = work done = change in kinetic energy = k

$$\frac{1}{2}mv^2 = \frac{1}{2} \times 50 \times (5)^2 = 625\,\text{J}$$

And heat gained i.e.

$$Q_2 = m'L = 80 \times m' \times 4.2$$

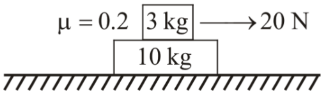
∵ Heat lost = heat gained

$$\therefore Q_1 = Q_2$$

$$625 = m' \times 80 \times 4.2$$

$$m' = 1.86\,\text{g}$$

702. A 3 kg block is placed over a 10 kg block and both are placed on a smooth horizontal surface. The coefficient of friction between the blocks is 0.2. If a horizontal force of 20 N is applied to 3 kg block, accelerations of the two blocks in ms^{-2} are ($g=10\ ms^{-2}$)



(a) $\frac{13}{4}, 0.6$ (b) $\frac{14}{4}, 3$
(c) $\frac{13}{4}, 3$ (d) $\frac{14}{3}, 0.6$

AP EAMCET(Medical)-2013

Ans. (d) : Given,
m = 3kg
M = 10 kg
μ = 0.2
F = 20 N
$g = 10\ m/s^2$

For block m = 3 kg

$ma_1 = F - f$

f = friction force

$3 \times a_1 = 20 - \mu mg$

$3 \times a_1 = 20 - 0.2 \times 3 \times 10$

$3a_1 = 20 - 6$

$3a_1 = 14$

$a_1 = \frac{14}{3}\ m/s^2$

For block M = 10 kg

$Ma_2 = f$

$Ma_2 = \mu mg$

$10a_2 = 0.2 \times 3 \times 10$

$a_2 = 0.6\ m/s^2$

Hence, $a_1 = \frac{14}{3}\ m/s^2$ and $a_2 = 0.6\ m/s^2$

703. A body of mass 300 kg is moved through 10 m along a smooth inclined plane of angle 30°. The work done in moving in joules is ($g=9.8ms^{-2}$)

(a) 4900 (b) 9800
(c) 14,700 (d) 2450

AP EAMCET(Medical)-2013

Ans. (c) : Given, mass (m) = 300 kg

θ = 30°

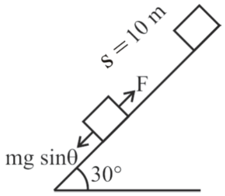
s = 10 m

$g = 9.8\ m/s^2$

F = mg sinθ

Work done (W) = F×s

W = mg×s×sinθ



W = 300 × 9.8 × sin30° × 10

$$W = 300 \times 9.8 \times \frac{1}{2} \times 10$$

W = 300 × 49

W = 14700 Joule

704. A block of mass m is placed on floor of a lift which is rough. The coefficient of friction between the block and the floor is μ. When the lift falls freely, the block is pulled horizontally on the lift floor. The force of friction

(a) zero (b) 2μ mg
(c) $\frac{1}{2}\mu$ mg (d) μ mg

AP EAMCET(Medical)-2012

Ans. (a) : When lift freely fall, N = 0

We know that, $f = \mu_s N$

$f = \mu_s \times 0$

Force of friction f = 0

@apna_pdf

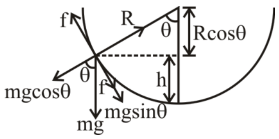
705. The coefficient of friction between a hemispherical bowl and an insect is $\sqrt{0.44}$ and the radius of the bowl is 0.6 m. The maximum height to which an insect can crawl in the bowl will be

(a) 0.4 m (b) 0.2 m
(c) 0.3 m (d) 0.1 m

AP EMCET(Medical)-2011

Ans. (d) : R = 0.6 cm

$\mu = \sqrt{0.44}$



From figure : R = mgcosθ

f = mgsinθ

$$\Rightarrow \quad \frac{f}{R} = \frac{mg\sin\theta}{mg\cos\theta} = \tan\theta$$

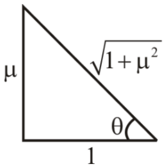
Also, $f = \mu R \Rightarrow \frac{f}{R} = \mu$

Hence, tanθ = μ

$$h = R - R\cos\theta = R[1-\cos\theta]$$

$$= R\left[1 - \frac{1}{\sqrt{1+\mu^2}}\right]$$

$$\Rightarrow \quad h = 0.6\left[1 - \frac{1}{\sqrt{1+0.44}}\right] = 0.6\left[\frac{1}{6}\right]$$



tanθ = μ

$$\cos\theta = \frac{1}{\sqrt{1+\mu^2}}$$

h = 0.1 cm

706. The rear side of truck is open and a box of mass 50 kg is placed at 3.2 m away from the open end. The coefficient of friction between the box. and the surface is 0.2. If the truck starts from rest and moves on a straight road with acceleration 2.1 ms^{-2}, then the box falls off the truck after a time (take g = 10ms^{-2})

(a) 4 s (b) $\frac{8}{\sqrt{41}}$ s
(c) 8 s (d) $\sqrt{8}$ s

AP EMCET(Medical)-2011

Ans. (c) : Acceleration due to pseudo force, a_p = 2.1 m/sec^2

Net acceleration, $a = a_p - \mu g$

Acceleration due to slipping between box and surface.

$$a = 2.1 - (0.2 \times 10) = 0.1$$

$$t = \sqrt{\frac{2s}{a}}$$

Where, a = 0.1 and s = 3.2

$$t = \sqrt{\frac{2(3.2)}{0.1}} = \sqrt{64}$$

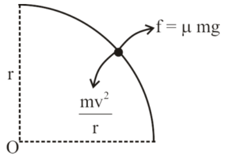
t = 8 sec

707. A car is traveling along a curved road of radius r. If the coefficient of friction between the tyres and the road is μ, the car will skid if its speed exceeds

(a) $2\sqrt{\mu rg}$ (b) $3\sqrt{\mu rg}$
(c) $\sqrt{2\mu rg}$ (d) $\sqrt{\mu rg}$

AP EMCET(Medical)-2010

Ans. (d) :



Let, Mass of car = m

Radius of curved road = r

For curved road–

Centripetal force = Psudo force

$F_c = F_r$

$$\frac{mv^2}{r} = \mu mg$$

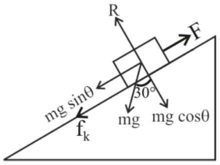
Speed $v = \sqrt{\mu rg}$

708. A body of mass 10 kg is lying on a rough plane inclined at an angle of 30° to the horizontal and the coefficient of friction is 0.5. The minimum force required to pull the body up the plane is

(a) 914 N (b) 91.4 N
(c) 9.14 N (d) 0.914 N

AP EMCET(Medical)-2008

Ans. (b) :



We know that,

$f_k = \mu N$

$= \mu mg\cos\theta$

According to question–

$F = f_k + mg\sin\theta$

$= \mu mg\cos\theta + mg\sin\theta$

$= \mu mg\cos 30° + mg\sin 30°$

$$= 5g \times \frac{\sqrt{3}}{2} + 10g \times \frac{1}{2}$$

$$= 5g + 5g \times \frac{\sqrt{3}}{2} = 5g\left(1 + \frac{\sqrt{3}}{2}\right)$$

$$= 5g\left[\frac{2+\sqrt{3}}{2}\right] = g(9.325)$$

F = 9.8 × 9.325

F = 91.4 N

@apna_pdf

709. A block of mass 2 kg is placed on the surface of a trolley of mass 20 kg which is on a smooth surface. The coefficient of friction between the block and the surface of the trolley is 0.25. If a horizontal force of 2 N acts on the block, the acceleration of the system in ms^{-2} is

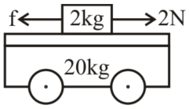
($g = 10\ ms^{-2}$)

(a) 1.8 (b) 1.0

(c) 0.9 (d) 0.09

AP EAMCET(Medical)-2007

Ans. (d) :



Given that,

Mass of block = 2 kg

Mass of trolley = 20 kg

We know that,

Friction (f) = μmg

$= 0.25 \times 2 \times 10$

f = 5 N

So friction force is greater than the applied force.

Hence, there is no relative motion between block and trolley.

$$\text{Acceleration, } a = \frac{F}{m+M}$$

$$a = \frac{2}{2+20} = \frac{2}{22} = \frac{1}{11}$$

$a = 0.09\ m/sec^2$

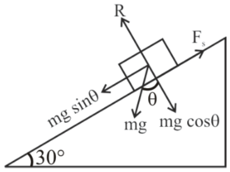
710. A block of wood resting on an inclined plane of angle 30°, just starts moving down. If the coefficients of friction is 0.2, its velocity (in ms^{-1}) after 5 s is: ($g=10\ ms^{-2}$)

(a) 12.75 (b) 16.35

(c) 18.25 (d) 20

AP EAMCET(Medical)-2006

Ans. (b) : Acceleration of block moving to down the plane is given by for the motion of body along the incline.



According to graph,

$ma = mg\sin\theta - \mu R$

$$a = \frac{mg\sin\theta - \mu mg\cos\theta}{m} \quad (R = mg\cos\theta \text{ and } f_s = \mu R)$$

$a = g\sin\theta - \mu g\cos\theta$

$a = 10 \sin 30^\circ - 0.2 \times 10 \cos 30^\circ$

$$a = 10 \times \frac{1}{2} - 2 \times \frac{\sqrt{3}}{2} = 3.278 ms^{-2}$$

From equation of motion,

V = u–at

∵ Velocity after 5 sec

V = 16.35 m/s

711. A 42 kg block of ice moving on rough horizontal surface stops due to friction, after sometime. If the initial velocity of the decelerating block is $4\ ms^{-1}$, the mass of ice (in kg) that has melted due to the heat generated by the friction is:

(Latent heat of ice is $3.36 \times 10^5\ J\ kg^{-1}$)

(a) 10^{-3} (b) 1.5×10^{-3}

(c) 2×10^{-3} (d) 2.5×10^{-3}

AP EAMCET(Medical)-2005

Ans. (a) : The kinetic energy of the ice block will be converted to the latent heat.

Given, $m = 42$ kg, $v = 4$ m/s, $L = 3.36 \times 10^5$ J/kg

K.E. = Required energy for change in state

K.E. = Q_L

$$\frac{1}{2}mv^2 = ML$$

$$\frac{1}{2} \times 42 \times 4 \times 4 = M \times 3.36 \times 10^5$$

$$M = \frac{42 \times 8}{3.36 \times 10^5}$$

$M = 10^{-3}$ kg

712. A cubical block of mass m rests on a rough horizontal surface, μ is the block and the surface. A force acting on the cube at an angle θ with the vertical side of the cube pulls the block. If the block is to be pulled along the surface, then the value cot (θ/2) is:

(a) less than μ

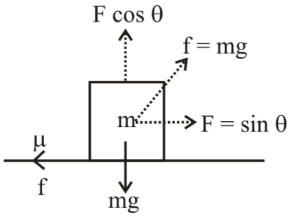
(b) greater than μ

(c) equal to μ

(d) not dependent on μ

AP EAMCET(Medical)-2005

Ans. (b) :



$N = mg - F\cos\theta$

$N = mg - mg\cos\theta$

$N = mg(1 - \cos\theta)$

$N = 2mg\sin^2\theta/2$ …..(i)

So the block is to be pulled along the surface, $F\sin\theta \geq \mu N$

$F\sin\theta \geq \mu\, 2mg\sin^2\theta/2$

$$F \times 2\sin\frac{\theta}{2}\cos\frac{\theta}{2} \geq \mu \times 2mg\sin^2\theta/2$$

$$mg\cos\frac{\theta}{2} \geq \mu mg.\sin\frac{\theta}{2}$$

$$\boxed{\cot\frac{\theta}{2} \geq \mu}$$

@apna_pdf

713. The minimum force required to move a body up an inclined plane of inclination 30º, is found to be thrice the minimum force required to prevent it from sliding down the plane. The coefficient of friction between the body and the plane is:

(a) $\frac{1}{\sqrt{3}}$ (b) $\frac{1}{2\sqrt{3}}$

(c) $\frac{1}{3\sqrt{3}}$ (d) $\frac{1}{4\sqrt{3}}$

AP EAMCET(Medical)-2004

Ans. (b) : To hold body stationary, force required.

$$F_1 = mg\sin\theta - \mu mg\cos\theta$$

The force required to move the body

$$F_2 = mg(\sin\theta + \mu\cos\theta)$$
$$F_2 = 3 \times F_1$$
$$mg(\sin\theta + \mu\cos\theta) = 3\,mg(\sin\theta - \mu\cos\theta)$$
$$2mg\sin\theta = 4mg\mu\cos\theta$$
$$\tan\theta = 2\mu$$
$$\mu = \frac{\tan\theta}{2}$$
$$\because \quad \theta = 30°$$
$$\mu = \frac{\tan 30°}{2}$$
$$\boxed{\mu = \frac{1}{2\sqrt{3}}}$$

714. A cannon of mass 1000 kg, located at the base of an inclined plane fires a shell of mass 100kg in a horizontal direction with a velocity 180km/h. The angle of inclination of the inclined plane with the horizontal is 45º. The coefficient of friction between the cannon and the inclined plane is 0.5. The height, in meter, to which the cannon ascends the inclined plane as a result of the recoil is: ($g = 10\ m/s^2$)

(a) $\frac{7}{6}$ (b) $\frac{5}{9}$

(c) $\frac{2}{6}$ (d) $\frac{1}{6}$

AP EAMCET(Medical)-2004

Ans. (a) : Given,

$$m_1 = 100\text{kg}, \quad m_2 = 1000\text{ kg}$$
$$u = 180\text{ km/h} = 180 \times \frac{5}{18} = 50\text{m/s}$$

Hence, velocity of cannon form conservation of momentum is-

$$m_2u_2 = m_1u_1$$
$$u_2 = \frac{m_1u_1}{m_2} = \frac{100 \times 50}{1000} = 5\text{m/s}$$

Acceleration along inclined plane in upward motion,

$$a = g(\sin\theta + \mu\cos\theta)$$
$$= 10(\sin 45^o + 0.5 \times \cos 45^o)$$
$$= 10\left(\frac{1}{\sqrt{2}} + 0.5 \times \frac{1}{\sqrt{2}}\right) = \frac{10 \times 1.5}{\sqrt{2}} = \frac{15}{\sqrt{2}}$$

The height of the cannon ascends the inclined as a results of recoil,

$$v^2 = u^2 - 2as \qquad (u_2 = u = 5\text{ m/s}, v = 0)$$
$$s = \frac{v^2}{2a} = \frac{(5)^2}{2 \times \frac{15}{\sqrt{2}}}$$
$$\boxed{s = \frac{5\sqrt{2}}{6}\text{m} \approx \frac{7}{6}\text{m}}$$

715. A horizontal force, just sufficient to move a body of mass 4kg lying on a rough horizontal surface is applied on it. The coefficients of static and kinetic friction between the body and the surface are 0.8 and 0.6 respectively. If the force continues to act even after the block has started moving, the acceleration of the block is ($g = 10m/s^2$)

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) 2 (d) 4

AP EAMCET(Medical)-2003

Ans. (c) : As mentioned in question, the applied force is just sufficient to move the body.

So applied force = Static friction force,

$$F_{\text{applied}} = \mu_s mg$$

As we know, kinetic friction force is always lesser than the static friction force.

So kinetic friction force, when it start to move is,

$$F_k = \mu_k mg$$
$$\therefore \quad F = F_{\text{applied}} - F_k$$
$$F = (\mu_s - \mu_k)\,mg$$
$$F = (0.8 - 0.6) \times 4 \times 10$$
$$= 0.2 \times 4 \times 10$$
$$F = 8\text{ N}$$

So, $$a = \frac{F}{m} = \frac{8}{4} = 2\,\text{m/s}^2$$

716. A body moves along a circular path of radius 5 m. The coefficient of friction between the surface of the path and body is 0.5. The angular velocity in rad/s with which the body should move so that it does not leave the path is ($g=10m/s^2$)

(a) 4 (b) 3

(c) 2 (d) 1

AP EAMCET(Medical)-2002

Ans. (d) : $\mu mg = m\omega^2 r$

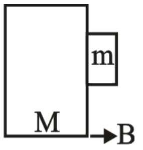
$$0.5 \times 10 = \omega^2 \times 5$$
$$\omega^2 = \frac{5}{5} = 1$$

Angular velocity $\omega = 1$

$\because \quad \omega$ = Angular velocity

717. Consider a mass M moving in the positive x-direction with an acceleration α as shown below. The minimum acceleration needed to hold a smaller mass m stationary with respect to M on the vertical side of M is (Assume that the surfaces of M and m in contact are rough)

@apna_pdf

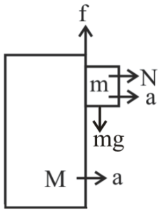


(a) $\frac{g}{m}$ (b) $\frac{g}{M}$

(c) 3g (d) $\frac{g}{\mu}$

AP EAMCET(Medical)-2009

Ans. (d) : The pseudo force developed the normal force on smaller block.



According to question,

$$f = \mu N$$
$$= \mu ma$$

Friction force equal to wait of the block,

$$f = mg$$
$$\mu ma = mg$$
$$a = \frac{g}{\mu}$$

718. A block of weight 200 N is pulled along a rough horizontal surface at constant speed by force 100 N, acting at an angle 30° above the horizontal. The coefficient of kinetic friction between the block and surface is:

(a) 0.43 (b) 0.58

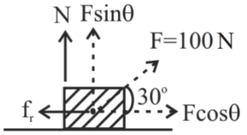
(c) 0.75 (d) 0.83

AP EAMCET(Medical)-2001

Ans. (b) :

$$N + F\sin\theta = mg$$
$$N = mg - F\sin\theta$$

Also, $f_r = \mu N = \mu(mg - F\sin\theta)$



$$F\cos\theta = \mu(mg - F\sin\theta)$$
$$\mu = \frac{F\cos 30^\circ}{mg - F\sin 30^\circ}$$
$$\mu = \frac{100\times\frac{\sqrt{3}}{2}}{200 - 100\times\frac{1}{2}} = \frac{1}{\sqrt{3}}$$
$$\mu = 0.58$$

719. Consider the following two statements A and B, identify the correct choice in given answers:

A: For a body resting on a rough horizontal table, it is easier to pull at an angle than push at same angle to cause motion.

B: A body sliding down a rough inclined plane of inclination, equal to angle of friction has non-zero acceleration.

(a) both A and B are true

(b) A is true but B is false

(c) A is false but B is true

(d) both A and B are false

AP EAMCET(Medical)-2001

Ans. (b) : A is true because frictional force increases when we push a body at an angle because one component of force increases the normal force. While B is false because the normal force acting on a body sliding down an inclined plane is $mg\cos\theta$ but component along the inclined plane is $mg\sin\theta$. Also, by the angle of friction, $\tan\theta = \mu$

Therefore the weight component along the inclined plane and the friction force will be equal. So, the body would not accelerate, ($a = 0$).

Thus, option (b) is correct.

i.e. A is true but B is false.

720. A body of mass 5kg rest on a rough horizontal surface of coefficient of friction 0.2. The body is pulled through a distance of 10m by a horizontal force of 25N. The Kinetic energy acquired by it is:

(a) 200J (b) 150J

(c) 100J (d) 50J

AP EAMCET(Medical)-2000

Ans. (b) : The kinetic energy acquired by body (K.E).

= Total work done on the body against friction

$$= F \times s - \mu\, mg \times s$$
$$= 25 \times 10 - 0.2 \times 5 \times 10 \times 10$$
$$= 250 - 100$$
$$\text{K.E.} = 150 \text{ Joule}$$

721. A body is projected along a rough horizontal surface with a velocity 6m/s. If the body comes to rest after travelling a distance 9m, the coefficient of sliding friction is ($g = 10\ ms^{-2}$) :

(a) 0.5 (b) 0.6

(c) 0.4 (d) 0.2

AP EAMCET(Medical)-1998

Ans. (d) : From Newton's 2nd law,

$$F_{net} = ma$$

Retardation, $a = \frac{\mu mg}{m} = 10\mu$

Now, $v^2 = u^2 + 2as$

$$0 = (6)^2 - 2\times 10\,\mu\times 9$$
$$0 = 36 - 180\,\mu$$
$$\mu = \frac{36}{180} = 0.2$$

@apna_pdf

722. A van is moving with a speed of 72km/h on a level road. Where the coefficient of friction between its tyres and road is 0.5. The minimum radius of curvature, that the road must have, for safe driving of van is ($g = 10ms^{-2}$):

(a) 80m (b) 40m

(c) 20m (d) 4m

AP EAMCET(Medical)-1999

Ans. (a) : Given,

Speed of van, v = 72 km/h

$$v = 72 \times \frac{5}{18} = 20\ m/s$$

Coefficient of friction, $\mu = 0.5$

$$\mu\ mg = \frac{mv^2}{r}$$

$$\mu g = \frac{v^2}{r}$$

$$0.5 \times 10 = \frac{v^2}{r}$$

$$\frac{v^2}{r} = 5$$

$$r = \frac{v^2}{5}$$

$$r = \frac{20 \times 20}{5}$$

Radius of curvature, r = 80 m

723. Two bodies having the same mass 2 kg each, have different surface areas $50 m^2$ and $100\ m^2$ in contact with a horizontal plane. If the coefficient of friction is 0.2, the forces of friction that come into play when they are in motion will be in the ratio:

(a) 1:1 (b) 1:2

(c) 2:1 (d) 1:4

AP EAMCET(Medical)-1999

Ans. (a) :

(N = w = mg)

Motion → Kinetic force of friction

$f_k = \mu N = \mu\ mg$

f_k is independent of area of surface of a body

$f_{k_1} = \mu m_1 g = 0.2 \times 2 \times g$

$f_{k_2} = \mu m_2 g = 0.2 \times 2 \times g$

So,

$$\frac{f_{k_1}}{f_{k_2}} = \frac{0.2 \times 2 \times g}{0.2 \times 2 \times g} = \frac{1}{1}$$

$$\boxed{f_{k_1} : f_{k_2} = 1:1}$$

724. A ladder 2.5 m long and 150 N weight has its centre of gravity 1 m from the bottom. A weight 40 N is attached to the top end. The work required to raise the ladder from the horizontal position to the vertical position is:

(a) 190 J (b) 250 J

(c) 285 J (d) 475 J

AP EAMCET(Medical)-1999

Ans. (b): Work done is equal to increase in potential energy in,

(1) Raising the weight 150 N of the ladder through a height 1 m.

(2) Raising a weight 40 N through 2.5 m.

$W_1 = F_1.s_1 = 150 \times 1 = 150$ Joule

And $W_2 = F_2.s_2 = 40 \times 2.5 = 100$ Joule

$W = W_1 + W_2$

$W = 150 + 100$

Work $W = 250$ Joule

725. A body of mass 10 kg lies on a rough horizontal surface. When a horizontal force of f newton acts on it, it gets an acceleration of $5 m/s^2$ and when the horizontal force is doubled, it gets an acceleration of $18\ m/s^2$. Then the coefficient of friction between the body and the horizontal surface is: (assume $g = 10ms^{-2}$)

(a) 0.2 (b) 0.8

(c) 0.4 (d) 0.6

AP EAMCET(Medical)-1997

Ans. (b) : $F - 10\ \mu g = 50$ ....(i)

$2\ F - 10\ \mu g = 180$ .... (ii)

From equation (ii) – 2 × equation (i),

$10 \mu g = 80$ $\left(\because g = 10\, m/s^2\right)$

$100 \mu = 80$

$\mu = 80/100$

$\mu = 0.8$

726. Keeping the banking angle same, to increase the maximum speed with which a vehicle can travel on a curved road by 10 percent the radius of curvature of the road has to be changed from 20 m to

(a) 6 m (b) 18 m

(c) 24.2 m (d) 30.5 m

EAMCET-1991

Ans. (c) : For speed v, we have

$$\tan\theta = \frac{v^2}{rg} = \frac{v^2}{20g} \quad ...(i)$$

If $v_2 = v + 0.1v = 1.1v$

then,

$$\tan\theta = \frac{v_2^2}{r_2 g} = \frac{(1.1v)^2}{r_2 g} \quad ...(ii)$$

Since the banking angle is constant,

Equating eq^n (i) and (ii)

$$\frac{1}{20} = \frac{1.21}{r_2}$$

$r_2 = 20 \times 1.21 = 24.2$ m

727. The banking angle for a curved road of radius 490 m for a vehicle moving at $35\ ms^{-1}$ is

(a) $\tan^{-1}(0.25)$ (b) $\tan^{-1}(0.55)$

(c) $\tan^{-1}(0.45)$ (d) $\tan^{-1}(0.75)$

EAMCET-1992

@apna_pdf

Ans. (a) :
Here, $v = 35\ ms^{-1}$,
$r = 490$ m

$$\therefore \quad \tan\theta = \frac{v^2}{rg} = \frac{(35)^2}{490\times 9.8} = 0.25$$

or $\quad \theta = \tan^{-1}(0.25)$

728. The maximum speed with which a car can be driven round a curve path of a radius 18 m without skidding (when g = 10 ms^{-2} and the coefficient of friction between rubber tyres and the roadways is 0.2) is

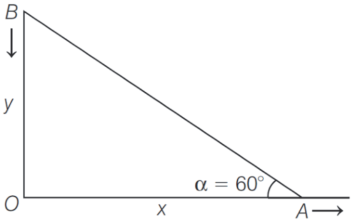
(a) 36.0 kmh^{-1} (b) 18.0 kmh^{-1}
(c) 21.6 kmh^{-1} (d) 14.4 kmh^{-1}

EAMCET-1998

Ans. (c) : Centripetal force = Frictional force

$$\frac{mv^2}{r} = \mu mg$$
$$v = \sqrt{\mu rg}$$
$$v = \sqrt{0.2\times 18\times 10}$$
$$v = 6\,m/s$$
$$v = 21.6\,kmph$$

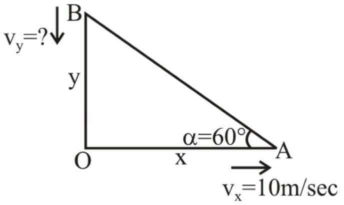
729. Two particles A and B are connected by a rigid rod AB. The rod slides along perpendicular rails as shown here. The velocity of A to the right is 10 m/s. What is the velocity of B when angle α =60° ?



(a) 9.8 m/s (b) 10 m/s
(c) 5.8 m/s (d) 17.3 m/s

[AIPMT 1998]

Ans. (d) :



Given, v_x = 10m/sec
Angle (α) = 60°
Let the velocity along x and y axes be v_x and v_y respectively,

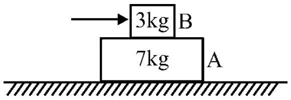
$$\therefore \quad v_x = \frac{dx}{dt} \text{ and } v_y = \frac{dy}{dt}$$

From figure,
$\tan\alpha = y/x$
$\Rightarrow \quad y = x\tan\alpha \qquad .....(i)$

Differentiating equation (i) with respect to t, we get–

$$\frac{dy}{dt} = \frac{dx}{dt}\tan\alpha$$
$$v_y = v_x \tan 60°$$
$$v_y = 10\times\sqrt{3}$$
$$v_y = 10 \times 1.731$$
$$v_y = 17.31 \text{ m/sec}$$

730. Two blocks A and B are placed one over the other on a smooth horizontal surface. The maximum horizontal force that can be applied on the upper block B, so that A and B move without separation is 49N. The coefficient of friction between A and B is



(a) 0.2 (b) 0.3 (c) 0.5 (d) 0.8

Manipal UGET-2016

Ans. (c) : Given,
F = 49N
Mass of block A (M_A) = 7 kg
Mass of block B (M_B) = 3 kg
Then coefficient of friction between A and B = μ
The equation of motion of two block systems,
$F = \mu(M_A + M_B).g$

$$\mu = \frac{F}{(M_A+M_B).g}$$

Where M_A and M_B are the masses of the blocks.

$$\mu = \frac{49}{(7+3)\times 9.8}$$
$$\mu = \frac{49}{(10)\times 9.8} = \frac{49}{98}$$
$$\mu = 0.5$$

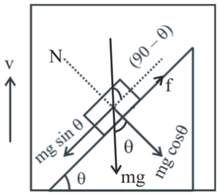
So, coefficient of friction b/w two blocks A and B is 0.5.

731. A small block of mass m is kept on a rough inclined surface of inclination θ fixed in a elevator. The elevator goes up with a uniform velocity v and the block does not slide on the wedge. The work done by the force of friction on the block in time t will be:

(a) zero (b) mgvt $\cos^2\theta$
(c) mgvt $\sin^2\theta$ (d) mgvt sin 2θ

BITSAT-2014

Ans. (c): Displacement of the block in time t, d = vt
Force, f = mgsinθ
Work done by friction is-
We know that,
$W_f = Fd\cos\theta = (mg\sin\theta).(vt).\cos(90 - \theta)$
$W_f = mgvt\sin^2\theta$



@apna_pdf

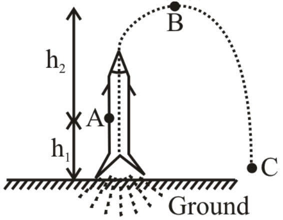
(g) System of Varying Mass (Rocket)

732. A rocket is fired vertically from the ground with a resultant vertical acceleration of $10ms^{-2}$. Fuel is finished in 1 min and it continues to move up. What is the maximum height reached?

(a) 36.4 km (b) 42.3 km
(c) 48.4 km (d) 25.6 km

AP EAMCET (21.09.2020) Shift-II
AIIMS 2018

Ans. (a) : Given,
Resultant vertical acceleration, $a = 10\ ms^{-2}$,
Time 't' = 1 min = 60sec.



Where, h_1 and h_2 are distance from the ground.
When rocket goes at height h_1 in 1 min (60s), then from equation of motion,

$$s = ut + \frac{1}{2}at^2$$

$$h_1 = ut + \frac{1}{2}at^2 \quad (\because\ s = h_1)$$

$$h_1 = 0 \times 60 + \frac{1}{2} \times 10 \times (60)^2 \quad (\because \text{ Initial velocity } u = 0)$$

$$h_1 = 18000\ m = 18km$$

Velocity of rocket after 1 min (60s),
From equation of motion,

$$v = u + at = 0 + 10 \times 60 = 600\ ms^{-1}$$

After 1 min, when fuel of rocket is finished then

$$u = 600\ ms^{-1},\ a = -g = -9.8\ m/s^2$$

Hence, if rocket goes at height h_2, then
From equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2gh_2 \quad (\because\ s = h_2)$$

$$0 - (600)^2 = 2(-9.8)h_2$$

$$h_2 = \frac{360000}{2 \times 9.8}$$

$$h_2 = 18367.34\ m = 18.4\ km$$

∴ Maximum height travelled by rocket from ground

$$h_{max} = h_1 + h_2 = 18 + 18.4 = 36.4\ km$$

733. The motion of a rocket in upward direction with high speed is based on the principle of conservation of

(a) angular momentum (b) kinetic energy
(c) linear momentum (d) mass

MHT-CET 2020

Ans. (c) : The motion of a rocket in upward direction with high speed is based on the principle of conservation of linear momentum.

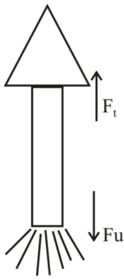
$\because$ $F = ma$
And $p = mv$

Then $F = \frac{dp}{dt}$

$$F = \frac{d}{dt}(mv)$$

$$F_{thrust} = v\frac{dm}{dt}$$

$$\left\{\frac{dm}{dt} \neq 0\right\}$$



734. In a rocket, fuel burns at a the rate of 1 kg/s. This fuel is ejected from the rocket with a velocity of 60 km/s. The force exerted on the rocket by this is

(a) 60 N (b) 600 N
(c) 6000 N (d) 60000 N

AP EAMCET (21.09.2020) Shift-I

Ans. (d) : Given,

$$\frac{dm}{dt} = 1kg/s$$

$$v = 60\ km/s = 60000\ m/s$$

Force = Rate of change in momentum

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt}$$

$$F = v\frac{dm}{dt} = 60000 \times 1 = 60000N$$

735. A rocket is launched straight up from the surface of the earth. When its altitude is $\frac{1}{3}$ of the radius of the earth, its fuel runs out and therefore it coasts. If the rocket has to escape from the gravitational pull the earth, the minimum velocity with which it should coast is (Escape velocity on the surface of the earth is $11.2\ kms^{-1}$.)

(a) $11.2\ kms^{-1}$ (b) $10.7\ kms^{-1}$
(c) $9.7\ kms^{-1}$ (d) $8.7\ kms^{-1}$

AP EAMCET (22.04.2019) Shift-I

Ans. (c) : Given,
Escape velocity on the surface of the earth is,

$$v_e = \sqrt{2gR_e} = 11.2\ kms^{-1}$$

Where,
Radius of earth = R_e,
Mass of earth = M_e
Mass of Rocket = m

Height of rocket from the surface of the earth is, $h = \frac{R_e}{3}$

@apna_pdf

Then, potential energy at the altitude $\frac{R_e}{3}$ = Kinetic energy.

$$\frac{GM_e m}{R_e+h} = \frac{1}{2}m(v'_e)^2$$

$\{v_e'$ = Escape velocity of rocket from $R_e/3\}$

$$\frac{GM_e}{R_e+\frac{R_e}{3}} = \frac{1}{2}(v'_e)^2$$

$$\frac{3}{4}\frac{GM_e}{R_e} = \frac{1}{2}v'^2_e$$

$$\left\{\because\ g = \frac{GM_e}{R_e^2} \Rightarrow GM_e = gR_e^2\right\}$$

$$\therefore \quad \frac{3}{4}\frac{gR_e^2}{R_e} = \frac{1}{2}(v'_e)^2$$

$$\frac{3}{4}\times 2gR_e = (v'_e)^2$$

$$\frac{3}{4}\times v_e^2 = (v'_e)^2 \qquad (\because\ v_e^2 = 2gR_e)$$

$$\frac{3}{4}\times 11.2\times 11.2 = (v'_e)^2$$

$$(v_e')^2 = 94.08$$

$$v'_e = \sqrt{94.08}\ \text{kms}^{-1}$$

$$v'_e = 9.699 = 9.67\ \text{kms}^{-1}$$

736. A rocket is about to launch upwards from its platform. The engine ejects gas at a rate of 2100 kg/s and the molecules are expelled at 50 km/s. If the above condition is just sufficient to make it rise upwards the mass of the rocket is (Assume g = 10 m/s^2)

(a) 12.6×10^5 kg (b) 15.5×10^6 kg
(c) 9.8×10^5 kg (d) 10.5×10^6 kg

TS EAMCET 02.05.2018, Shift-II

Ans. (d) : Force, $F = \frac{\Delta P}{\Delta t} = \frac{\Delta(mu)}{\Delta t} = u\cdot\frac{\Delta m}{\Delta t}$

From Newton third law of motion,

$$F_1 = F_2$$

$$mg = u\left(\frac{\Delta m}{\Delta t}\right)$$

$$m = \frac{u}{g}\left(\frac{\Delta m}{\Delta t}\right)$$

$$m = \frac{50\times1000}{10}\times(2100)$$

$$m = 10.5\times10^6\ \text{kg}$$

737. A rocket with an initial mass m_0 is going up with a constant acceleration a by exhausting gases with a velocity v relative to the rocket motion, then the mass of the rocket at any instant of time is (assume that no other forces act on it)

(a) $m = m_0e^{-\frac{at}{v}}$ (b) $m = m_0e^{-\frac{2at}{v}}$
(c) $m = m_0e^{-\frac{at}{2v}}$ (d) $m = m_0e^{-\frac{a^2t^2}{v^2}}$

AP EAMCET (23.04.2018) Shift-2

Ans. (a) : Given,
External forces on rocket is zero ($F_{ext} = 0$).
External force = Rate of change in momentum

$$F_{ext} = \frac{dp}{dt} = \frac{d(mv)}{dt}$$

$$F_{ext} = m\frac{dv}{dt} + v\frac{dm}{dt}$$

$$m\frac{dv}{dt} + v\frac{dm}{dt} = 0$$

$$\left(\text{Where}\frac{dv}{dt} = a\right)$$

$$\therefore \quad ma = -v\frac{dm}{dt}$$

$$\frac{-a}{v}dt = \frac{dm}{m}$$

Integrating both side

$$\frac{-a}{v}\int_0^t dt = \int_{m_0}^{m}\frac{dm}{m}$$

$$-\frac{a}{v}[t]_0^t = [\log_e m]_{m_0}^{m}$$

$$\frac{-at}{v} = \log_e\frac{m}{m_0}$$

$$\frac{m}{m_0} = e^{-at/v}$$

$$m = m_0e^{-at/v}$$

738. A rocket is intended to leave the Earth's gravitational field. The fuel in its main engine is a little less than the amount that is necessary and an auxiliary engine, (only capable of operating for a short time) has to be used as well. When is it best to switch on the auxiliary engine?

(a) at take-off
(b) When the rocket has nearly stopped with respect to the Earth
(c) It doesn't matter.
(d) Can't say

JIPMER-2017

Ans. (a) : For a space rocket, most of its thrust is required during take off. The rocket combustion gaseous fuel to burn and result in decrease of weight.
Rocket further accelerate using less fuel So it best to switch on the auxiliary engine at take off.
The energy released during the operation of the engines increases the total energy of the rocket, and the rocket can leave, the earth's gravitational field if the sum of its potential and kinetic energies becomes positive.

739. A 600 kg rocket is set for a vertical firing. If the exhaust speed is 1000 ms^{-1}, the mass of the gas ejected per second to supply the thrust needed to overcome the weight of rocket is

(a) 117.6 kg s^{-1}
(b) 58.6 kg s^{-1}
(c) 6 kg s^{-1}
(d) 76.4 kg s^{-1}

AIPMT- 1990

@apna_pdf

Ans. (c) : Given, m = 600 kg

v = 1000 ms^{-1}

Force required to overcome the weight of rocket is,

$$F = mg$$

$$\frac{dp}{dt} = mg$$

$$\frac{d(mv)}{dt} = mg$$

$$v\frac{dm}{dt} = mg \qquad \left[\because \frac{dv}{dt} = 0\right]$$

$$\frac{dm}{dt} = \frac{mg}{v}$$

$$\frac{dm}{dt} = \frac{600\times 10}{1000}$$

$$\frac{dm}{dt} = 6\ \text{kgs}^{-1}$$

740. If the force on a rocket moving with a velocity of 300m/s is 345 N, then the rate of combustion of the fuel is

(a) 0.55 kg/s
(b) 0.75 kg/s
(c) 1.15 kg/s
(d) 2.25 kg/s

AIPMT- 1995

Ans. (c) : Given that,

v = 300m/s

F = 345N.

$$\frac{dm}{dt} = ?$$

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt} = \text{Rate of change in}$$
momentum

$$F = v\frac{dm}{dt} \qquad \left[\because \frac{dv}{dt} = 0\right]$$

$$345 = 300\ \frac{dm}{dt}$$

$$\frac{dm}{dt} = \frac{345}{300}$$

$$\frac{dm}{dt} = 1.15\text{kg/s}$$

741. A satellite in a force free space sweeps stationary interplanetary dust at a rate. $\left(\frac{dM}{dt}\right) = \alpha v$. The acceleration of satellite is

(a) $-\frac{2\alpha v^2}{M}$
(b) $-\frac{\alpha v^2}{M}$
(c) $-\frac{\alpha v^2}{2M}$
(d) $-\alpha v^2$

AIPMT- 1994

Ans. (b) : Given, $\frac{dM}{dt} = \alpha v$

From, Newton's second law of motion

$$F = \frac{dp}{dt}$$

$$F = \frac{d}{dt}(Mv)$$

$$F = M\frac{dv}{dt} + v\frac{dM}{dt}$$

Given the space is force free then net force is zero (F = 0),

$$0 = M\frac{dv}{dt} + v\frac{dM}{dt} \qquad \text{........ (i)}$$

We know that, $a = \frac{dv}{dt}$

From equation (i),

$$0 = Ma + v(\alpha v)$$

$$-Ma = \alpha v^2$$

$$a = -\frac{\alpha . v^2}{M}$$

742. Physical independence of force is a consequence of

(a) Third law of motion
(b) Second law of motion
(c) First law of motion
(d) All of these

AIPMT- 1991

Ans. (c) : Newton's first law of motion states that body are in motion or in rest then body remains in their position until unless external frees does not applied.
So, physical independence of force is a consequence of 'Newton's first law of motion'.

743. The force on a rocket moving with a velocity 300 m/s is 210 N. The rate of consumption of fuel of rocket is

(a) 0.7 kg/s
(b) 1.4 kg/s
(c) 0.07 kg/s
(d) 10.7 kg/s

AIPMT- 1999

Ans. (a) : Given that,

F = 210 N

v = 300 m/s

$$\frac{dm}{dt} = ?$$

From Newton's second law of motion,
Force (F) = Rate of change in momentum

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt}$$

$$F = v\frac{dm}{dt} \qquad \left[\because \frac{dv}{dt} = 0\right]$$

$$\frac{dm}{dt} = \frac{F}{v} = \frac{210}{300}$$

$$\frac{dm}{dt} = 0.7\ \text{kg/s}$$

744. A 5000 kg rocket is set for vertical firing. The exhaust speed is 800 ms^{-1}. To give an initial upward acceleration of 20 m/s^2, the amount of gas ejected per second to supply the needed thrust will be (g = 10ms^{-2})

(a) 127.5 kg s^{-1}
(b) 187.5 kg s^{-1}
(c) 185.5 kg s^{-1}
(d) 137.5 kg s^{-1}

UPSEE- 2009
AIPMT- 1998

@apna_pdf

Ans. (b) : Given,
Mass of rocket (m) = 5000kg,
Acceleration of rocket (a) = 20 m/s^2,
Speed of rocket (v) = 800 m/s, g = 10 m/s^2
We know that, thrust force on rocket–

$$F_{thrust} = v_r \times \left(\frac{-dm}{dt}\right)$$

Force acted on rocket

$$F_{net} = F_t - W$$

$$ma = v_r \times \left(\frac{-dm}{dt}\right) - mg$$

$$\left(\frac{-dm}{dt}\right) = \frac{m(g+a)}{v_r}$$

$$\left(\frac{-dm}{dt}\right) = \frac{5000(10+20)}{800} = 187.5\,kg/s$$

745. A bullet is fired from a gun. The force on the bullet is given by F = 600 – 2 × 10^5 t, where F is in Newton and t in second. The force on the bullet becomes zero as soon as it leaves the barrel. What is the average impulse imparted to the bullet?

(a) 9 N-s
(b) Zero
(c) 0.9 N-s
(d) 1.8 N-s

AIPMT- 1998

Ans. (c) : Given, $F = 600 - 2\times10^5\,t$
At F = 0, $t = 3\times10^{-3}$ sec

Since, $\text{Impulse} = \int_0^t F.dt$

$$= \int_0^t \left(600 - 2\times10^5 t\right)dt$$

$$= \left[600t - 2\times10^5 \frac{t^2}{2}\right]$$

Putting the value of $t = 3 \times 10^{-3}$ s
Impulse $= 600 \times 3 \times 10^{-3} - 10^5 (3 \times 10^{-3})^2$
$= 1.8 - 0.9 = 0.9$ N s

746. A rocket of mass 1000 kg is to be projected vertically upwards. The gases are exhausted vertically downwards with velocity 100 ms^{-1} with respect to the rocket. What is the minimum rate of burning of fuel, so as to just lift the rocket upwards of fuel, so as to just lift the rocket upwards against, the gravitational attraction? (Take g = 10ms^{-2})

(a) 50 kgs^{-1}
(b) 100 kgs^{-1}
(c) 200 kgs^{-1}
(d) 400 kgs^{-1}

UPSEE - 2014

Ans. (b) : Given,
m = 1000 kg
v = 100 ms^{-1}
g = 10 ms^{-2}
Since, fuel is continuous Burning,
∴ Rate of change of mass rocket = Rate of Burning fuel

$$\therefore F_{min} = \frac{d}{dt}(mv) = \frac{dm}{dt}\times v$$

$F_{min} = mg = 1000 \times 10 = 10000$ N

$$\frac{10000}{100} = \frac{dm}{dt}$$

$$\therefore \frac{dm}{dt} = 100\,kg\,s^{-1}$$

747. Diwali rocket is ejecting 50 g of gases/sec at a velocity of 400 m/s. The accelerating force on the rocket will be

(a) 22 dyne
(b) 20 N
(c) 20 dyne
(d) 100 N

JCECE-2008

Ans. (b) : Given,
v = 400 m/s

$$\frac{dm}{dt} = 50\times10^{-3}\,\text{kg/sec}$$

Let accelerating force on rocket be F,

$$\therefore \quad F = V\frac{dm}{dt}$$

$$F = 400\times50\times10^{-3} = 20N$$

$$\therefore \quad F = 20\,N$$

748. Diwali rocket is ejecting 50 g of gases/s at a velocity of 400 m/s. The accelerating force on the rocket will be

(a) 22 dyne
(b) 20 N
(c) 20 dyne
(d) 100N

UP CPMT-2008

Ans. (b) : Given, $\frac{\Delta m}{\Delta t} = 50g = 0.05\,kg$, u = 400 m/sec.

The accelerating force on the rocket $= \frac{\Delta m}{\Delta t}.u$

Accelerating force = 0.05 × 400
= 20 N

749. The engine of a jet aircraft applies a thrown force of 10^5 N during take off and causes the plane to attain a velocity of 1 km/s in 10 s. The mass of the plane is

(a) 10^{2}kg
(b) 10^3 kg
(c) 10^4 kg
(d) 10^5 kg

JIPMER-2012

Ans. (b) : Acceleration produced in jet $= \frac{\text{Velocity}}{\text{time}}$

$$a = \frac{1000}{10} = 100\,m/sec^2$$

Newton's second law.

$$F = ma$$

$$10^5 = m\times100$$

$$m = \frac{10^5}{100}$$

$$m = 10^3\,kg$$

750. Diwali rocket is ejecting 50 g of gases/s at a velocity of 400 m/s. The acceleration force on the rocket will be

(a) 22 dyne
(b) 20 N
(c) 20 dyne
(d) 100 N

UPSEE - 2007

Ans. (b) : Given,
Mass of ejecting gases (Δm) = 50g= 50 ×10^{-3} kg,
velocity (v) = 400 m/s
The accelerating force = upward thrust

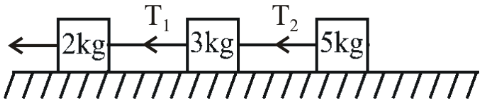
$$= \frac{\Delta m}{\Delta t}.v$$

$$= \frac{50\times10^{-3}}{1}\times400 = 20\text{ N}$$

@apna_pdf

(h) Motion of Body Connected Together

751. Three blocks of masses 2 kg, 3 kg and 5 kg are connected to each other with light string and are then placed on a frictionless surface as shown in the figure. The system is pulled by a force = 10N, then tension T_1 =



(a) 1 N (b) 5 N
(c) 8 N (d) 10 N

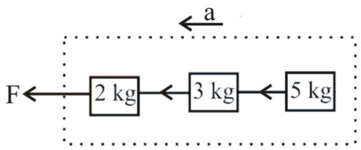
Manipal UGET-2019, 2017, 2014
BCECE-2008

Ans. (c) : Given,

$F = 10$ N,

$m_1 = 2$ kg, $m_2 = 3$ kg, $m_3 = 5$ kg

Acceleration of total system = a m/s^2



$$\therefore \quad F = \text{Total mass} \times \text{acceleration}$$

$$F = (m_1 + m_2 + m_3) \times a$$

$$10 = (2+3+5) \times a$$

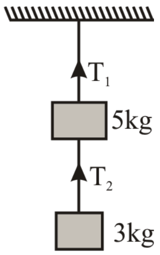
$$a = 1 \text{m/s}^2$$

$$T_1 = (m_2 + m_3) \times a$$

$$T_1 = (3 + 5) \times 1$$

$$T_1 = 8 \text{ N}$$

752. Two masses of 5 kg and 3 kg are suspended with the help of massless inextensible strings as shown in figure, when whole system is going upwards with acceleration 2m/s^2, the value of T_1 is (use g = 9.8 m/s^2)



(a) 23.6 N (b) 59 N
(c) 94.4 N (d) 35.4 N

Karnataka CET-2022

Ans. (c) : Given,
Upwards acceleration (a) = 2m/s^2
Free body diagram of 3 kg and 5 kg masses are-

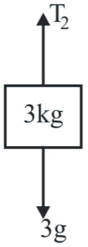


figure (i)

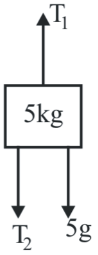


figure (ii)

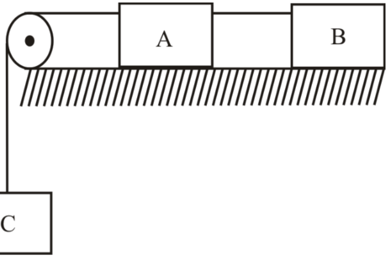
Then, from figure (i)

$$T_2 = 3a + 3g$$
$$T_2 = 3(a + g)$$
$$T_2 = 3 \times (2 + 9.8)$$
$$T_2 = 35.4 \text{ N}$$

From figure (ii)

$$T_1 - T_2 - 5g = 5a$$
$$T_1 = 5(a + g) + T_2$$
$$T_1 = 5 \times (2 + 9.8) + 35.4$$
$$T_1 = 94.4 \text{ N}$$

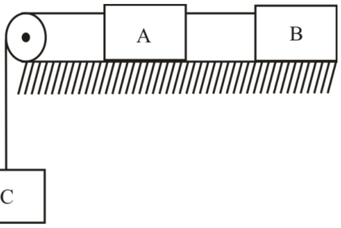
753. Three bodies A, B and C of masses 10 g each are tied to a thread-pulley system as shown in the figure. Assume the masses of the pulley and the threads are negligible and there is no friction in the pulley. If the co-efficient of friction between the bodies A and B with the horizontal surface is 0.1. then the acceleration with which the body C comes down is [Acceleration due to gravity =10 ms^{-2}]



(a) $\frac{2}{3}$ ms^{-2} (b) $\frac{8}{3}$ ms^{-2}
(c) $\frac{1}{3}$ ms^{-2} (d) $\frac{4}{3}$ ms^{-2}

AP EAMCET-11.07.2022, Shift-II

Ans. (b) : According to the question,



Given, mass of each block = 10 g = 0.01 kg, μ = 0.1
Acceleration of block 'c'

$$a = \frac{\text{Net pulling force}}{\text{total mass}}$$

@apna_pdf

$$a = \frac{m_C g - (f_A + f_B)}{m_A + m_B + m_C}$$

$$a = \frac{0.01 \times 10 - \mu m g \times 2}{3 \times 0.01}$$

$$a = \frac{0.1 - 0.1 \times 0.01 \times 10 \times 2}{0.03}$$

$$a = \frac{0.10 - 0.02}{0.03} = \frac{0.08}{0.03}$$

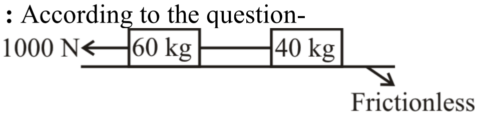
$$a = \frac{8}{3}\ \text{ms}^{-2}$$

754. Two rectangular blocks of masses 40 kg and 60 kg are connected by a string and kept on a frictionless horizontal table. If a force of 1000 N is applied on 60 kg block away from 40 kg block, then the tension in string is

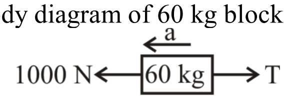
(a) 450 N (b) 400 N
(c) 350 N (d) 500 N

AP EAMCET-04.07.2022, Shift-I

Ans. (b) : According to the question-



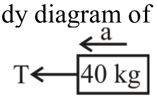
Free body diagram of 60 kg block



$1000 - T = 60\ a$

$1000 - 60\ a = T$ ....(i)

Free body diagram of 40 kg block



$T = 40\ a$ ....(ii)

From equation (i) and (ii)

$1000 - 60\ a = 40\ a$

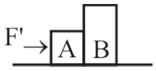
$100\ a = 1000$

$a = 10\ m/s^2$

Then, tension $(T) = 40 \times a$

$= 40 \times 10 = 400$ N

755. A constant horizontal force $\vec{F}$ of magnitude 10 N is applied to a block A and this produces an acceleration of magnitude 20 m/s^2. If this block A is then kept against another block B of mass 1.5 kg as shown in figure and a force F' of 20 N is applied, find the force on the block B. Neglect friction.



(a) 15 N (b) 10 N
(c) 20 N (d) 5 N

TS EAMCET 19.07.2022, Shift-II

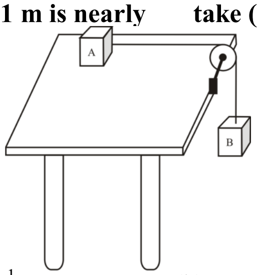
Ans. (a) : $F_A = F = m_A a_A$

$$m_A = \frac{F_A}{a_A} = \frac{10}{20} = 0.5$$

$$F_B = m_B . a_B = \frac{m_B F'}{m_A + m_B}$$

$$F_B = \frac{1.5 \times 20}{1.5 + 0.5} = 15N$$

756. In the arrangement shown in the figure, m_A=1kg and m_B =4kg. Assume that the string is light and inextensible and the pulley is smooth. If the coefficient of friction between block 'A' and the table is 0.2. the speed of both the blocks when 'B' has descended through a height h=1 m is nearly take (g = 10 m.s^{-2})



(a) 4 m.s^{-1} (b) 8 m.s^{-1}
(c) 6 m.s^{-1} (d) 2 m.s^{-1}

AP EAMCET-03.09.2021, Shift-II

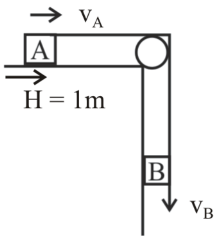
Ans. (a) : Given, $m_A = 1$ kg, $m_B = 4$ kg, $\mu = 0.2$

$v = v_A = v_B$

Friction (f) $= \mu mg$

$= 0.2 \times 1 \times 10$

$= 2$ N



Net work done = change in energy

$W_{Net} = \Delta E$

$-$ Friction $\times H = \Delta KE + \Delta U$

$-2 \times 1 = 1/2\ (m_A + m_B)\ v^2 + mg\ (-H)$

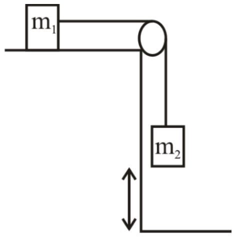
$-2 = 1/2\ (1+4)\ v^2 + 4 \times 10 \times (-1)$

$$38 = \frac{1}{2} \times 5\ v^2$$

$v = 3.9$ m/s ≈ 4 m/s

$v = 4$ m/s

757. Consider two masses m_1 and m_2 are connected through a pulley. Mass 'm_2' starts from rest at height 'h' and falls down. With what speed it hits the ground?
(Assume no friction and massless string & pulleys)



(a) $\sqrt{\left(\frac{m_2}{m_1 + m_2}\right) gh}$ (b) $\sqrt{2gh}$

(c) $\sqrt{\left(\frac{m_2}{m_1 + m_2}\right) 2gh}$ (d) $\sqrt{\left(\frac{m_1}{m_1 + m_2}\right) 2gh}$

TS EAMCET 04.08.2021, Shift-II

@apna_pdf

Ans. (c) :

$F_1 = T = m_1a$

$F_2 = W_2 - T = m_2a$

$m_1a + m_2a = T + W_2 - T$

$m_1a + m_2a = W_2$

$m_1a + m_2a = m_2g$

$$a = \left(\frac{m_2}{m_1 + m_2}\right)g$$

From the eq^n, $v^2 - u^2 = 2as$

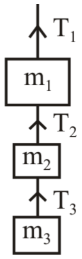
$v^2 = 2as$

$$v^2 = 2\left(\frac{m_2}{m_1 + m_2}\right)gh$$

$$v^2 = \left(\frac{m_2}{m_1 + m_2}\right)2gh$$

$$v = \sqrt{\left(\frac{m_2}{m_1 + m_2}\right)2gh}$$

758. Three masses m_1, m_2 and m_3 are connected to a rope as shown in figure. It $m_1 = 5kg$, $m_2 = 2kg$ and $m_3 = 3kg$ and the whole system is going upward with as acceleration of $2m/s^2$, then the value of the tension T_1 will be ($g = 10\ m/s^2$)



(a) 20 N (b) 80 N

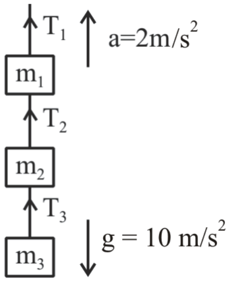
(c) 100 N (d) 120 N

Assam CEE-2020

Ans. (d): Given,

$m_1 = 5kg$, $m_2 = 2kg$, $m_3 = 3kg$

$a = 2\ m/s^2$ $g = 10m/s^2$



Tension T_1 due to mass m_1, m_2, m_3 and upward acceleration "a".

$T_1 = (m_1 + m_2 + m_3) \times (g + a)$

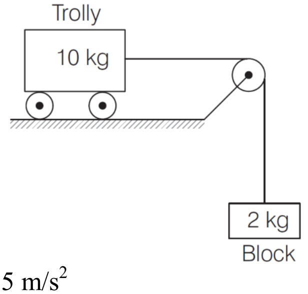
$T_1 = (5 + 2 + 3) \times (10 + 2)$

$T_1 = 10 \times 12$

$T_1 = 120$ N

The value of tension T_1 is 120 Newton.

759. Calculate the acceleration of the block and trolly system shown in the figure. The coefficient of kinetic friction between the trolly and the surface is 0.05. ($g = 10\ m/s^2$, mass of the string is negligible and no other friction exists).



(a) $1.25\ m/s^2$

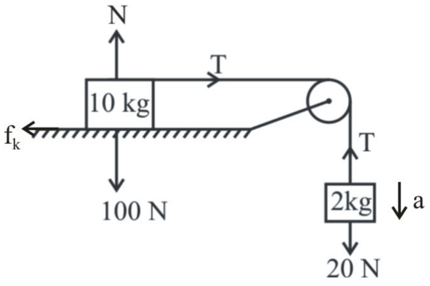
(b) $1.50\ m/s^2$

(c) $1.66\ m/s^2$

(d) $1.00\ m/s^2$

NEET- (Oct.) 2020

Ans. (a) :



Given, kinetic friction

$\mu = 0.05$

For block 2kg,

$F_{net} = ma$

$20 - T = 2a$ ....(i)

For block 10 kg,

$T - f_k = 10a$

$T - \mu_kN = 10a$ ($f_k = \mu_kN$ and $N = 100$ N)

$T - (0.05 \times 100) = 10a$

$T - 5 = 10a$ ....(ii)

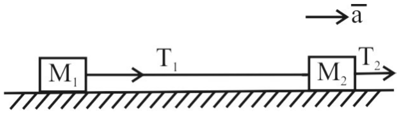
From eqn (i) and (ii)

$20 - T + T - 5 = 2a + 10a$

$$a = \frac{15}{12}$$

$a = 1.25\ ms^{-2}$

760. Two masses M_1 and M_2 are accelerated uniformly on frictionless surface as shown in figure. The ratio of the tensions $\frac{T_1}{T_2}$ is



(a) $\frac{M_1}{M_1 + M_2}$ (b) $\frac{M_1}{M_2}$

(c) $\frac{M_1 + M_2}{M_2}$ (d) $\frac{M_2}{M_1}$

MHT-CET 2020

@apna_pdf

Ans. (a) : From the above figure.

$T_1 = M_1 . a$ ....(i)

Where a → acceleration

And, $T_2 - T_1 = M_2 . a$ ....(ii)

From eq. (i) and (ii)

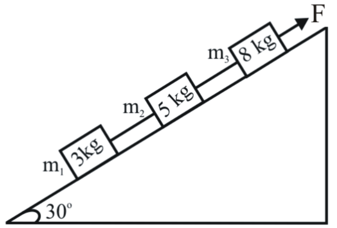
$T_2 - M_1a = M_2a$

$T_2 = (M_1 + M_2)a$

Hence,

$$\therefore \quad \frac{T_1}{T_2} = \frac{M_1 a}{(M_1 + M_2)a} = \frac{M_1}{M_1 + M_2}$$

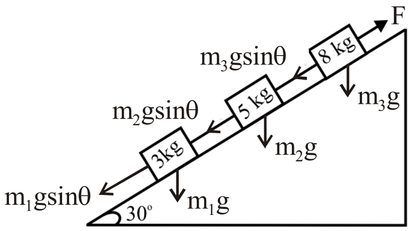
761. Three blocks are connected by massless strings on a frictionless inclined plane of 30° as shown in the figure. A force of 104 N is applied upward along the incline to mass m_3 causing an upward motion of the blocks. What is the acceleration of the blocks? (Assume, acceleration due to gravity, g = 10 m/s^2)



(a) 6.0 m/s^2 (b) 4.5 m/s^2
(c) 3.0 m/s^2 (d) 1.5 m/s^2

TS-EAMCET-03.05.2019, Shift-1

Ans. (d) :



$F - (m_1g\sin\theta + m_2g\sin\theta + m_3g\sin\theta) = (m_1 + m_2 + m_3) \times a$

$104 - (3g\sin 30° + 5g\sin 30° + 8g\sin 30°) = (3 + 5 + 8) \times a$

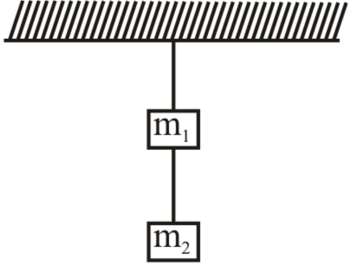
$104 - (3 + 5 + 8)\, g \sin 30 = 16a$

$104 - 16 \times 10 \times \frac{1}{2} = 16a$

$24 = 16\, a$

$$\therefore \quad a = \frac{24}{16}, \quad a = 1.5\, m/s^2$$

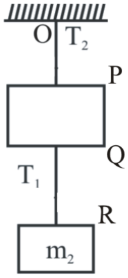
762. Two masses connected in series with two massless strings are hanging from a support as shown in the figure. Find the tension in the upper string



(a) m_1g (b) $(m_1 - m_2)g$
(c) m_2g (d) $(m_1 + m_2)g$
(e) $(m_1 \times m_2)g$

Kerala CEE-2019

Ans. (d): Two masses m_1 & m_2 are hanging from a support as shown in figure-



The tension is in string QR,

T_1= Total mass hanging on string × g = m_2 g

Similarly,

The tension is in string OP,

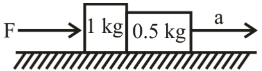
T_2= Total mass hanging on string OP × g= $(m_1+m_2)g$

$T_2 = (m_1 + m_2)g$

Hence the tension in upper string is,

$T = (m_1 + m_2)g$

763. A 1 kg block and a 0.5 kg block move together on a horizontal frictionless surface. Each block exerts a force of 6 N on the other. The block move with a uniform acceleration of

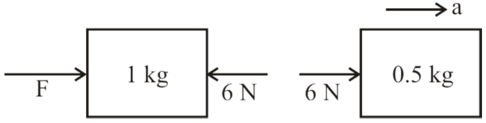


(a) 3 ms^{-2} (b) 6 ms^{-2}
(c) 9 ms^{-2} (d) 12 ms^{-2}

AIIMS-27.05.2018(E)

Ans. (d) : Given,

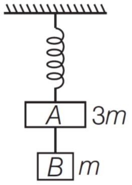
$m_1 = 1$ kg, $m_2 = 0.5$ kg



$6 = 0.5 \times a$

$a = 12\, m/s^2$

764. Two blocks A and B of masses 3m and m respectively are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in figure. The magnitudes of acceleration of A and B immediately after the string is cut, are respectively



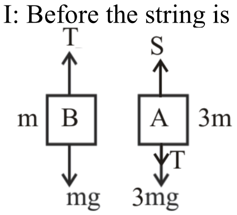
(a) $g, \frac{g}{3}$ (b) $\frac{g}{3}, g$

(c) g, g (d) $\frac{g}{3}, \frac{g}{3}$

NEET- 2017

@apna_pdf

Ans. (b) : Case- I: Before the string is cut-



FBD before cutting the string

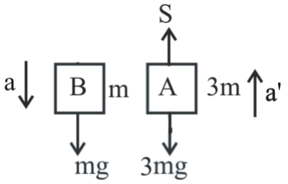
For block A, $S = T + 3mg$ ….(i)

For block B, $T = mg$

Put the value T = mg in equation (i), we get

$S = mg + 3mg = 4\ mg$

Case II : After the string is cut –



FBD after cutting the string

Using Newton's second law of motion for block B, we have-

$ma = mg$

$a = g$

Again using Newton's second law of motion for block A, we have .

$S - 3mg = 3ma'$

By substituting S = 4 mg in the above equation we get-

$4\ mg - 3mg = 3\ ma'$

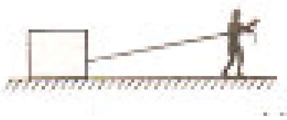
$3ma' = mg$

$$a' = \frac{mg}{3m}$$

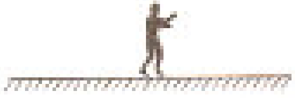
$$a' = \frac{g}{3}$$

Therefore, the magnitudes of acceleration of block A and B immediately after the sting is cut are $\frac{g}{3}$ (in upward direction) and g (in downward direction) respectively.

765. Assertion: A man and a block rest on smooth horizontal surface. The man holds a rope which is connected to block. The man cannot move on the horizontal surface.



Reason: A man standing at rest on smooth horizontal surface cannot start walking due to absence of friction (The man is only in contact with floor as shown).



(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) Assertion is incorrect, but reason is correct.

AIIMS-2017

Ans. (d) : If the man standing on a smooth surface, he cannot initiate walking since there will be no horizontal force to support the motion. In absence of friction force man will continue to slip on the surface.

Hence, Assertion is incorrect, but reason is correct.

766. A body of the mass 50 kg is suspended using a spring balance inside a lift at rest. If the lift starts falling freely, the reading of the spring balance is :

(a) < 50 kg (b) = 50 kg

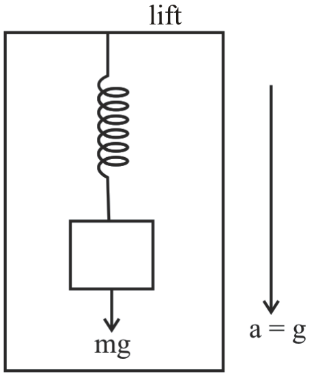
(c) > 50 kg (d) = 0

Karnataka CET-2017

Ans. (d) : Given,

Mass of the body, m = 50kg

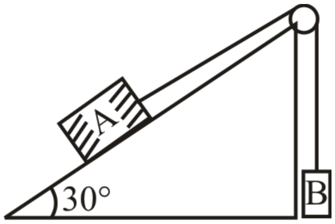
As the lift is freely falling thus its acceleration in downward direction. (wightlessness)



Reading of the spring balance = apparent weight of mass

$m(g - a) = 50(g - g) = 0$

767. Two blocks are connected over a mass less pulley as shown in fig. The mass of block A is 10 kg and the coefficient of kinetic friction is 0.2. Block A slides down the incline at constant speed. The mass of block B in kg is:



(a) 3.5 (b) 3.3

(c) 3.0 (d) 2.5

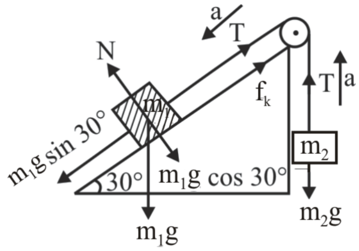
BITSAT-2010

@apna_pdf

Ans. (b) : Mass of block (m_1) = 10 kg

Kinetic friction (μ_k) = 0.2

$a = 0$



For block of mass m_2

$T = m_2g = 10m_2$ ……(i)

From the figure

Resolving the forces perpendicular to the plane

$N = m_1g\cos 30^o$ ……(ii)

We know

$f_k = \mu_k N = 0.2 \times m_1 g\cos 30^o$ [From eq^n. (ii)]

$$f_k = 0.2 \times 10 \times 10 \times \frac{\sqrt{3}}{2}$$

$f_k = 10\sqrt{3}$ N

Resolving the forces parallel to the plane

$T + f_k = m_1g\sin 30^o$ ……(iii)

Putting the value f_k and T in equation (iii)

$$10\,m_2 + 10\sqrt{3} = 10 \times 10 \times \frac{1}{2}$$

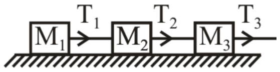
$$m_2 + \sqrt{3} = 5$$

$$m_2 = \left(5 - \sqrt{3}\right)$$

$m_2 = 3.269$ kg

$m_2 \approx 3.3$kg

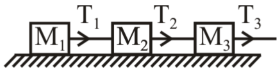
768. Three blocks of masses m_1, m_2 and m_3 are connected by massless strings, as shown, on a frictionless table. They are pulled with a force T_3 = 40 N. If m_1 = 10 kg, m_2 = 6 kg and m_3 = 4 kg, the tension T_2 will be



(a) 20 N (b) 40 N
(c) 10 N (d) 32 N

BITSAT-2011
Manipal UGET-2011

Ans. (d) : Given m_1 = 10 kg, m_2 = 6 kg, m_3 = 4 kg, T_3 = 40 N



Total mass of system = $m_1+m_2+m_3$ =20 kg

$$\therefore \quad a = \frac{F}{m}$$

$$a = \frac{40}{20} = 2\,m/s^2$$

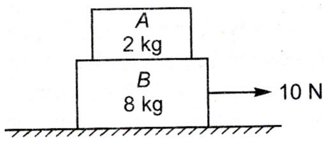
Because string T_2 pulls m_1 and m_2 block.

$T_2 = (m_1+m_2)a$

$T_2 = (10+6)\times 2$

T_2 = 32 N

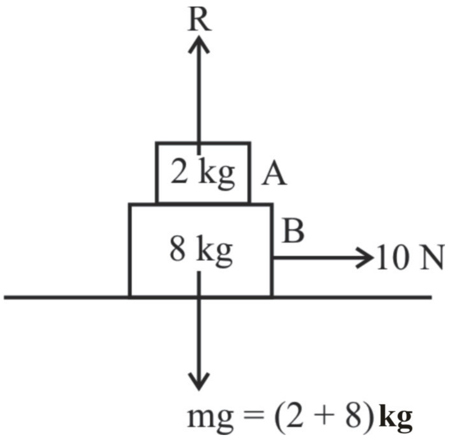
769. Block A of mass of 2 kg is placed over block B of mass 8 kg. The combination is placed over a rough horizontal surface. Coefficient of friction between B and the floor is 0.5. Coefficient of friction between blocks A and B is 0.4. A horizontal force of 10 N is applied on block B. The force of friction between blocks A and B is ($g = 10\ ms^{-2}$)



(a) 100 N (b) 40 N
(c) 50 N (d) Zero

Karnataka CET-2011

Ans. (d) : Given,



Total mass

m = (2 + 8)

= 10 kg

weight = mg = R

R = 10 × 10

R = 100 N

Friction force between both block

$F_f = \mu R$

= 0.5 × 100 = 50 N

$10N < F_f$

Thus, a force of 10N is unable to start the motion of the system. So, there is no relative motion between A & B. Hence, the friction force between the block A and blocks B is zero.

770. A block of weight 4 kg is resting on a smooth horizontal plane. If it is struck by a jet of water at the rate of 2 kgs^{-1} and at the speed of 10 ms^{-1}, then the initial acceleration of the block is

(a) 15 ms^{-2} (b) 10 ms^{-2}
(c) 2.5 ms^{-2} (d) 1 ms^{-2}
(e) 5 ms^{-2}

KERALA CEE 2012

@apna_pdf

Ans. (e) : Given,

Mass (m) = 4 kg

Smooth horizontal surface,

Jet water rate $\left(\frac{dm}{dt}\right)$ = 2 kg/sec.

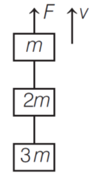
Speed (v) = 10 m/sec.

So, $F = \frac{dm}{dt}.v = 2\times10 = 20\text{ N}$

& F = ma

$a = \frac{F}{m} = \frac{20}{4} = 5\text{m/sec}^2$

771. Three blocks with masses m, 2m and 3m are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m? (g is the acceleration due to gravity).



(a) zero (b) 2 mg

(c) 3 mg (d) 6 mg

NEET- 2013

Ans. (a) : As all blocks are moving with constant speed. Therefore acceleration is zero. So, net force on each block is zero.

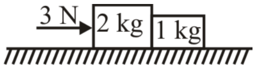
v = Constant

∴ a = 0

We know that, F = ma

F = 0

772. Two blocks of 2 kg and 1 kg are in contact on a frictionless table. If a force of 3 N is applied on 2 kg block, then the force of contact between the two block will be

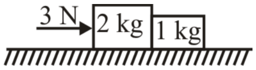


(a) 0 N (b) 1 N

(c) 2 N (d) 3 N

WBJEE-2010

Ans. (b) :



We know,

F = ma

Then, common acceleration of the system,

$a = \frac{F}{m_1 + m_2} = \frac{3}{2+1}$

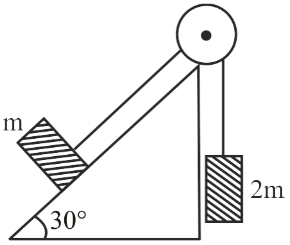
$a = \frac{3}{3}$

a = 1 m/s^2

Therefore, force is applied to 2 kg then it act on 1 kg block will be

$F_N = ma = 1 \times 1 = 1\text{N}$

773. Two blocks of masses m and 2m are connected by a light string passing over a frictionless pulley. As shown in the figure, the mass m is placed on a smooth inclined plane of inclination 30° and 2m hangs vertically. If the system is released, the blocks move with an acceleration equal to



(a) g/4 (b) g/3

(c) g/2 (d) g

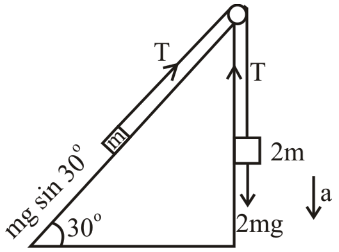
AMU-2009

Ans. (c) : In downward,

2mg– T = 2 ma ……..(i)

And

mg sin 30° – T = –ma …….(ii)



Subtracting both equation,

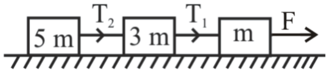
$2mg - \frac{mg}{2} = 3ma$

$3a = \frac{ug - g}{2}$

$3a = \frac{3g}{2}$

$a = \frac{g}{2}$

774. In the given figure, three blocks are connected by massless cords. Masses of the block are m, 3m ad 5m and they are pulled by a force F on a frictionless horizontal surface. If the tension T_1 = 16 N, then T_2 is equal to :



(a) 6 N (b) 10 N

(c) (80/3) N (d) 18 N

AMU-2006

@apna_pdf

Ans. (b) : Given, $T_1 = 16$ N,

$m_1 = m, \quad m_2 = 3m, \quad m_3 = 5m$

$T_2 = ?$

Acceleration "a" due to tension T_1 in mass m_2 and m_3

$$a = \frac{T_1}{m_2 + m_3} = \frac{16}{3m + 5m}$$

$$a = \frac{2}{m}$$

Now, tension

$$T_2 = m_3 \times a$$

$$T_2 = 5m \times \frac{2}{m}$$

$$T_2 = 10 \text{ N}$$

So, tension T_2 is equal to 10 N.

775. The apparent weight of a person in a lift moving downwards is half his apparent weight the same lift moving upwards with the same acceleration. Acceleration of the lift is

(a) g (b) $\frac{g}{4}$

(c) $\frac{g}{2}$ (d) $\frac{g}{3}$

AP EAMCET(Medical)-2012

Ans. (d) : Let's,

Mass of person = m

Acceleration = a

During downward and upward moving

Then,

Apparent weight during downward moving (W_{down})

$$W_{down} = m(g - a)$$

Apparent weight during upwards moving (W_{up})

$$W_{up} = m(g + a)$$

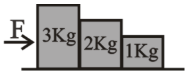
Given,

$$W_{down} = \frac{1}{2} W_{up}$$

Then, $$m(g - a) = \frac{1}{2} m(g + a)$$

$$a = \frac{g}{3}$$

776. Consider the following statement about the blocks, shown in the diagram, which are being pushed by a constant force on a frictionless table.



(A) All blocks move with the same acceleration

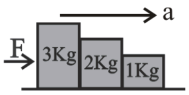
(B) The net force on each block is the same.

(a) A only (b) B only

(c) Both A and B (d) neither A nor B

AP EMCET(Medical)-2011

Ans. (a) : All masses are pushed by force F



Then, acceleration-

$$a = \frac{F}{\text{total mass}} = \frac{F}{m_1 + m_2 + m_3} = \frac{F}{3 + 2 + 1}$$

$$a = \frac{F}{6} \text{ m/s}^2$$

So, All block move with same acceleration $\frac{F}{6}$ m/s^2

Net force on mass, $m_1 = 3$ kg

$$F_1 = m_1.a = 3.\ \frac{F}{6} = \frac{F}{2}$$

$$F_1 = \frac{F}{2} \text{ N}$$

Net force on mass, $m_2 = 2$ kg

$$F_2 = m_2.a = 2.\ \frac{F}{6} = \frac{F}{3}$$

$$F_2 = \frac{F}{3} \text{ N}$$

Net force on mass, $m_3 = 1$ kg

$$F_3 = m_3.a = 1 \times \frac{F}{6} = \frac{F}{6}$$

$$F_3 = \frac{F}{6} \text{ N}$$

So, the net force on each block are different.

777. A person of 70kg mass is lifted by a helicopter with the help of rope, hanging from it. If the helicopter is rising up with an acceleration 4 ms^{-2} the tension in the rope is (taking g=10 ms^{-2})

(a) 250 N (b) 490 N

(c) 980 N (d) 1960 N

AP EAMCET(Medical)-1999

Ans. (c) : Given, m = 70 kg, a = 4ms^{-2}

Tension of rope T = m (g + a)

$$T = 70\ (10 + 4)$$

$$T = 980 \text{ N}$$

778. The weight of a man in a lift, moving upwards is 608 N while the weight of the same man in the lift moving downwards, with the same acceleration, is 368 N. His normal weight in newton is:

@apna_pdf

(a) 488 (b) 588
(c) 480 (d) 240

AP EAMCET(Medical)-1997

Ans. (a) : Given,

$$F_{up} = 608 \text{ N}, \quad F_{down} = 368 \text{ N}$$

In upward direction

$$F_{up} = m(g + a)$$

$$608 = m(g + a) \quad ....(i)$$

In downward direction

$$F_{down} = m(g - a)$$

$$368 = m(g - a) \quad ....(ii)$$

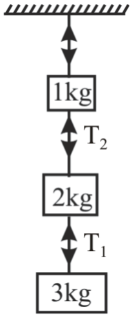
Adding both equation (i) and (ii),

$$976 = 2 \text{ mg}$$

$$\text{mg} = \frac{976}{2} = 488 \text{ N}$$

Normal weight (W) = mg = 488 N

779. In the system shown in the adjoining figure, the tension T_2 is

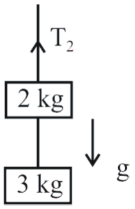


(a) g (b) 2g
(c) 5g (d) 6g

UPSEE - 2012

Ans. (c) : Given,

$$m_1 = 1 \text{ kg}, m_2 = 2 \text{ kg}, m_3 = 3 \text{ kg}$$



$\therefore$ $T_2 = (m_2 + m_3) \times g$

$$T_2 = (3 + 2) \times g$$

$$T_2 = 5g$$

780. Four blocks of same mass connected by cords are pulled by a force F on a smooth horizontal surface, as shown in figure. The tensions T_1, T_2 and T_3 will be

$$F \longleftarrow M \xleftarrow{T_1} M \xleftarrow{T_2} M \xleftarrow{T_3} M$$

(a) $T_1 = \frac{1}{4}F, T_2 = \frac{3}{2}F, T_3 = \frac{1}{4}F$

(b) $T_1 = \frac{1}{4}F, T_2 = \frac{1}{2}F, T_3 = \frac{1}{2}F$

(c) $T_1 = \frac{3}{4}F, T_2 = \frac{1}{2}F, T_3 = \frac{1}{4}F$

(d) $T_1 = \frac{3}{4}F, T_2 = \frac{1}{2}F, T_3 = \frac{1}{2}F$

UPSEE - 2009

Ans. (c) : Given,

$$m_1 = m_2 = m_3 = m_4 = M$$

$$\underset{\,}{F} \longleftarrow \underset{m_1}{M} \xleftarrow{T_1} \underset{m_2}{M} \xleftarrow{T_2} \underset{m_3}{M} \xleftarrow{T_3} \underset{m_4}{M}$$

F = total mass × acceleration

$$F = (m_1 + m_2 + m_3 + m_4) \times a$$

$$F = (M + M + M + M) \times a$$

$$a = \frac{F}{4M}$$

$$T_1 = (m_2 + m_3 + m_4) \times a$$

$$T_1 = 3M \times a = 3M \times \frac{F}{4M} = \frac{3}{4}F$$

$$T_2 = (m_3 + m_4) \times a$$

$$T_2 = 2M \times a = 2M \times \frac{F}{4M} = \frac{1}{2}F$$

$$T_3 = m_4 \times a$$

$$T_3 = M \times a = \frac{1}{4}F$$

781. An atom bomb weighing 1 kg explodes releasing 9×10^{13}J of energy. 'What percentage of mass is converted into energy?

(a) 0.1% (b) 1%
(c) 2% (d) 10%

UP CPMT-2013

Ans. (a) : Given,

$$E = 9 \times 10^{13} \text{ J}$$

$$c = 3 \times 10^8 \text{ ms}^{-2}$$

We know that,

$$E = mc^2$$

$$9 \times 10^{13} = m(3 \times 10^8)^2$$

$$m = \frac{9 \times 10^{13}}{(3 \times 10^8)^2} = \frac{9 \times 10^{13}}{9 \times 10^{16}}$$

$$m = 1 \times 10^{-3} \text{ kg}$$

$$\frac{\Delta m}{m} \times 100 = 10^{-3} \times 100 = 0.1\%$$

@apna_pdf

05. Work, Energy and Power

(a) Work done by Force and Power

1. A spherical body of mass 2 kg starting from rest acquires a kinetic energy of 10000 J at the end of 5th second. The force acted on the body is_______N.

JEE Main-24.01.2023, Shift-I

Ans. (40) : Given, mass of body (m) = 2kg,
Kinetic energy (K.E.) = 10000 J
We know that,

$$\text{Kinetic energy} = \frac{1}{2}mv^2 = 10000$$

$$\frac{1}{2} \times 2 \times v^2 = 10000$$

$$v = 100 \text{ m/s}$$

From first equation of motion –

$$v = u + at$$

$$100 = 0 + a \times 5$$

$$a = 20 \text{ m/s}^2$$

We know that, F = ma

$$F = 2 \times 20 = 40 \text{ N}$$

2. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = \left(t\hat{i} + 3t^2\hat{j}\right)N$, where $\hat{i}$ and $\hat{j}$ are the unit vectors along x and y axis. The power developed by above force, at the time t = 2s, well be _____W.

JEE Main-24.01.2023, Shift-II

Ans. (100) : Given, $\vec{F} = t\hat{i} + 3t^2\hat{j}$ and mass (m) = 1kg

We know that, $\vec{F} = m\vec{a}$

$$F = m\frac{d\vec{v}}{dt}$$

$$d\vec{v} = \frac{\vec{F}}{m}dt$$

$$\int_0^v d\vec{v} = \frac{1}{m}\int_0^t \vec{F}\,dt$$

$$\vec{v} = \int_0^t t\,dt\,\hat{i} + \int_0^t 3t^2\,dt\,\hat{j}$$

$$\vec{v} = \frac{t^2}{2}\hat{i} + t^3\hat{j}$$

Then, power = $\vec{F} \cdot \vec{v}$

$$P = \left(t\hat{i} + 3t^2\hat{j}\right)\left(\frac{t^2}{2}\hat{i} + t^3\hat{j}\right)$$

$$P = \frac{t^3}{2} + 3t^5$$

At, t = 2sec

$$P = \frac{8}{2} + 3 \times 32$$

$$P = 4 + 96$$

$$P = 100\text{W}$$

3. A water heater of power 2000 W is used to heat water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. The efficiency of heater is 70%. Time required to heat 2 kg of water from 10°C to 60°C is ____ S. (Assume that the specific heat capacity of water remains constant over the temperature range of the water.)

JEE Main-31.01.2023, Shift-II

Ans. (300) Given, Mass (m) = 2 kg
Power of heater (P) = 2000W
We know that,
Heat required (Q) = msΔT

$$= 2 \times 4200 \times (60 - 10) = 420000\text{J}$$

$$\text{Efficiency of power is } 70\% = \frac{70}{100} \times 2000 = 1400\text{W}$$

$$\because \text{ Time taken } = \frac{\text{Heat}}{\text{Power}} = \frac{420000}{1400} = 300\text{S}$$

4. A force F = (5+3y^2) acts on a particle in the y-direction, where F is in Newton and y is in meter. The work done by the force during a displacement from y = 2m to y = 5m is _____J.

JEE Main-01.02.2023, Shift-II

Ans. (132) : Given, $\vec{F} = \left(5 + 3y^2\right)$

We know that, W = F.d

$$\int dW = \int_2^5 \left(5 + 3y^2\right) \cdot dy$$

$$W = \left[5y + y^3\right]_2^5$$

$$W = \left[\left\{5(5) + (5)^3\right\} - \left\{5(2) + (2)^3\right\}\right]$$

$$W = (25+125) - (10+8)$$

$$W = 150 - 18 = 132 \text{ J}$$

5. A force acts on a 30 g particle in such a way that the position of the particle as a function of time is given by $x = \alpha t^2$, where x is in metre, t is in seconds and α = 1 m/s^2. The work done during the first 4 s is

@apna_pdf

(a) 0.96 J (b) 0.45 J
(c) 0.49 J (d) 0.53 J

TS-EAMCET-10.09.2020, Shift-1
TS-EAMCET.11.09.2020, Shift-2
TS-EAMCET.14.09.2020, Shift-2
TS-EAMCET-05.05.2018, Shift-2

Ans. (a) : Given, mass of particle (m) = 30g $=3\times10^{-2}$ kg

Displacement of the particle $(x) = \alpha t^2$, $\alpha = 1$ m/s^2

$$\therefore \text{Velocity } (v) = \frac{dx}{dt} = \frac{d}{dt}\left(\alpha t^2\right) = 2\alpha t$$

$$\text{Acceleration } (a) = \frac{dv}{dt} = \frac{d}{dt}(2\alpha t) = 2\alpha$$

∴ Force on the particle,

$$F = ma = 3\times10^{-2}\times2\alpha$$
$$= 6\times10^{-2}\,\text{N} \qquad [\therefore \alpha = 1]$$

∴ Work done during first 4 s,

$$W = \int_0^4 F\,dx$$
$$= \int_0^4 6\times10^{-2}\,dx$$
$$= 6\times10^{-2}\int_0^4 dx$$
$$= 6\times10^{-2}\int_0^4 v\,dt$$
$$= 6\times10^{-2}\int_0^4 2\alpha t\,dt$$
$$= 6\times10^{-2}\times2\alpha.\left[\frac{t^2}{2}\right]_0^4$$
$$= 12\times10^{-2}\times8 \qquad [\because \alpha = 1]$$
$$= 0.96\text{ J}$$

6. The power of a pump which can pump 200 kg of water to a height of 200 m in 10s is: ($g = 10$ m/s^2)

(a) 40 kW (b) 80 kW
(c) 4000 kW (d) 960 kW

CBSE PMT-2000
CPMT-1989
SCRA-1994
MH CET-2000
JIPMER-2002, 2001
AP EAMCET(Medical)-1998

Ans. (a) : Given,mass (m) = 200 kg, Height(h) = 200m
Time (t) = 10 sec, (g) = 10 m/s^2

We know that,

$$\text{power (P)} = \frac{\text{Work}}{\text{time}}$$

$$\text{So, the power of pump, } P = \frac{mgh}{t}$$

$$P = \frac{200\times10\times200}{10}$$
$$= 40000\text{ W}$$
$$P = 40\text{ kW}$$

7. A body moves a distance of 10 m along a straight line under the action of a force of 5 N. If the work done is 25 J the angle which the force makes with the direction of motion of the body is

(a) 0° (b) 30°
(c) 60° (d) 90°

Manipal UGET-2019
CG PET- 2006
NCERT-1980
JIPMER-1997
AIPMT-1999
BHU-2000
RPMT-2000
Odisha JEE-2002

Ans. (c): Given that,
Displacement, d = 10m,
Force, F = 5N,
Work done, W = 25J
We know that, W = F.d cosθ

$$25 = 5\times10\times\cos\theta$$
$$\cos\theta = \frac{1}{2}$$
$$\cos\theta = \cos60^{\circ}$$
$$\theta = 60^{\circ}$$

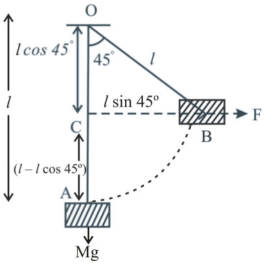
Then, force make angle (θ) = 60° with direction of motion.

8. A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string makes an angle of 45° with the initial vertical direction is

(a) $Mg(\sqrt{2}+1)$ (b) $Mg\sqrt{2}$
(c) $\frac{Mg}{\sqrt{2}}$ (d) $Mg(\sqrt{2}-1)$

UP CPMT-2008
AIEEE-2008
JCECE-2008
UPSEE-2007

Ans. (d) : Given that, mass = M kg, θ = 45°



Let, length of string is l

Work done is equal to gain in potential energy of mass

$$W = F\times l\sin45^{\circ} = \frac{Fl}{\sqrt{2}}$$

Change in potential energy = Mgh

$$= Mg\,(l - l\cos45^{\circ})$$
$$= Mg\,l\left(1-\frac{1}{\sqrt{2}}\right)$$

@apna_pdf

∵ Work done = Change in potential energy

$$\frac{Fl}{\sqrt{2}}=Mgl\left(1-\frac{1}{\sqrt{2}}\right)$$

$$F=Mg\left(\sqrt{2}-1\right)$$

9. 300 J of work is done in sliding a 2kg block up an inclined plane of height 10m. Taking g = 10 m/s^2, work done against friction is

(a) 200 J (b) 100 J
(c) Zero (d) 1000 J

JIPMER-2008
MP PMT-2002
CBSE PMT-2006
AFMC-2006

Ans. (b) : Net work done = work done against gravitational force + work done against frictional force.

$$W = W_g + W_f$$

$$W = W_f + mgh$$

$$300 = W_f + 2\times10\times10$$

$$W_f = 300-200$$

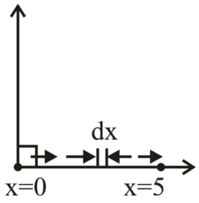
$$W_f = 100\text{ J}$$

10. When a position dependent force F = 7 – 2x + 3x^2 N acts on a small body of mass 2 kg and displaces it from x = 0 to x = 5 m, calculate the work done (in joules):

(a) 70 (b) 270
(c) 35 (d) 135

AP EAMCET-23.09.2020, Shift-II
Manipal UGET-2016
APMT -1992

Ans. (d) : Given, F = 7–2x+3x^2



Work done is given by

$$\int_0^W dw=\int_{x_1}^{x_2} F.dx$$

$$W=\int_0^5\left(7-2x+3x^2\right)dx$$

$$=\left[7x-\frac{2x^2}{2}+\frac{3x^3}{3}\right]_0^5$$

$$=\left[7x-x^2+x^3\right]_0^5$$

$= [7×5–5^2+5^3 – 0]$
$= 35–25+125$
$= 135$ J

11. A body is initially at rest. It undergoes one-dimensional motion with constant acceleration. The power delivered to it at time t is proportional to :

(a) $t^{1/2}$ (b) t
(c) $t^{3/2}$ (d) t^2

Karnataka CET-2020
Assam CEE-2014
BCECE-2006

Ans. (b) : Suppose m = mass of the body
a = acceleration produced in the body
v = velocity of the body
P = power delivered to the body in a time t

$v = u + at$
$v = at$ [∵ u = 0]

Force, F = ma

Power delivered to the body –

$P = F \times v$
$P = ma \times at$
$P = ma^2t$

So,

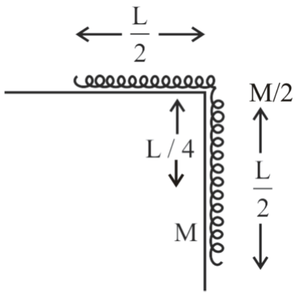
$P \propto t$

12. A uniform chain of mass M and length L is lying on a smooth horizontal table, with half of its length hanging down. The work done is pulling the entire chain up the table is

(a) $\frac{MgL}{2}$ (b) $\frac{MgL}{4}$
(c) $\frac{MgL}{8}$ (d) $\frac{MgL}{16}$

AP EAMCET (23.09.2020) Shift-I
BITSAT - 2009
AMU - 2004

Ans. (c): Given, mass = M, Length= L



mass of small part of chain = dm

$$dm=\frac{M}{L}dx$$

work done to pulling (dm) mass

$dw = dm\, g.x$

$$dw=\left(\frac{M}{L}.dx\right)g.x$$

$$dw=\frac{M}{L}gx\,dx$$

@apna_pdf

By integrating

$$dw = \frac{M}{L} g \int_0^{L/2} x\,dx$$

$$W = \frac{M}{L} g \left.\frac{x^2}{2}\right|_0^{L/2}$$

$$W = \frac{M}{L} g \frac{L^2/4}{2}$$

$$W = \frac{MgL}{8}$$

IInd Method–

Centre of mass at point M

As we know that,

Work done (W) = Change in energy

$W = \Delta E$

$W = Mg\,\Delta l$

$$\Delta l = \frac{1}{2} \times \frac{L}{2} = \frac{L}{4}$$

Now, as per given condition,

$$W = \frac{M}{2} \times g \times \frac{L}{4}$$

$$W = \frac{MgL}{8}$$

13. A ball is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t is proportional to

(a) $t^{1/2}$ (b) $t^{3/4}$

(c) $t^{3/2}$ (d) t^2

AP EAMCET-24.09.2020, Shift-I
BITSET - 2020
UPSEE - 2010

Ans. (c) :

For moving of a body along the straight line, machine need to deliver a constant power–

P = Force (F) × Velocity (v) ....(i)

$\because$ F = ma

and $\therefore$ $a = \frac{v}{t} = \frac{1}{t}\left(\frac{s}{t}\right)$

Acceleration, $a = \frac{s}{t^2}$, velocity, v = at

($\because$ Initial velocity, u = 0)

From, eq^n. (i), P = ma × v

$P = ma \times at$

$P = ma^2t$

$$P = \frac{ms^2}{t^3}$$

$$Pt^3 = ms^2$$

For constant power and mass distance will be–

$$s^2 \propto t^3$$

$$\boxed{s \propto t^{3/2}}$$

Where, s = distance moved by body
t = time

14. If a force F is applied on a body and it moves with a velocity v, the power will be

(a) F.v (b) $\frac{F}{v}$

(c) $\frac{F}{v^2}$ (d) $F.v^2$

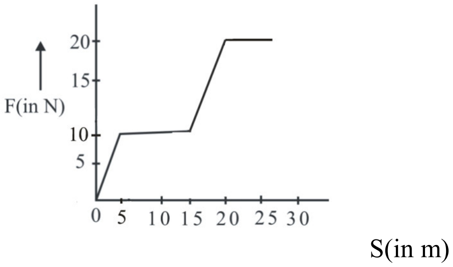
AP EAMCET (18.09.2020) Shift-I
UPSEE - 2004
AIIMS -1998

Ans. (a) : Power = Force × Velocity

P = F.v

Power can be define as a scalar product of force and velocity.

15. The work done by a force acting on a body is as shown in the graph. The total work done in covering an initial distance of 20 m is

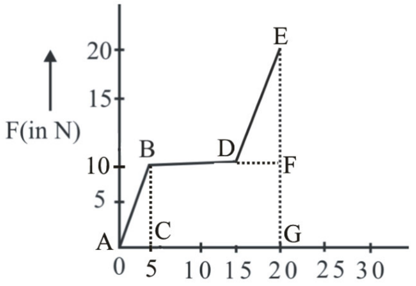


(a) 225 J (b) 200 J

(c) 400 J (d) 175 J

JIPMER-2012
Manipal UGET-2009
Karnataka CET-2009

Ans. (b):



Work done is equal to the area under the graph–

W = area of ABC + Area of BFGC + area of DEF

$$= \left(\frac{1}{2} \times 5 \times 10\right) + (15 \times 10) + \left(\frac{1}{2} \times 5 \times 10\right)$$

= 25 + 150 + 25

= 200 J

16. A body of mass 3 kg in under a force which caused displacement in it, given by $s = \frac{t^2}{3}$ in meter with time t in seconds. What is the work done by the force between time t = 0 and t = 2 is

(a) 8 J (b) 5.2 J

(c) 3.9 J (d) 2.6 J

SCRA-2009
WB JEE-2008
AIPMT-2006

@apna_pdf

Ans. (d) : Given,

Distance, $s = \frac{t^2}{3}$

$$\frac{ds}{dt} = \frac{2t}{3}$$

$$ds = \frac{2t}{3}dt$$

We know that-

$$\frac{ds}{dt} = \frac{2t}{3} = v$$

Also,

$$\frac{dv}{dt} = a$$

$$\therefore \quad a = \frac{d}{dt}\left(\frac{2t}{3}\right) = \frac{2}{3}$$

$$W = \int \vec{F}.\vec{ds} = \int F.ds$$

$$W = \int ma.ds$$

$$W = \int_0^2 3 \times \frac{2}{3} \times \frac{2t}{3} dt$$

$$W = \frac{4}{3}\int_0^2 t dt = \frac{4}{3}\left[\frac{t^2}{2}\right]_0^2$$

$$W = \frac{4}{6}[4] = \frac{16}{6}$$

$$W = 2.6 \text{ J}$$

17. A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. The work done by the force of gravity during the time the particle goes up is

(a) –0.5 J (b) – 1.25 J
(c) 1.25 J (d) 0.5 J

JCECE-2008
AIEEE-2008
UPSEE – 2007

Ans. (b) : Given, mass (m) = 100 g = 0.1 kg, u = 5 m/s
v = 0 m/s

From third equation of motion–

$$v^2 = u^2 + 2gh$$
$$0 = u^2 - 2gh$$
$$u^2 = 2gh$$

$$h = \frac{u^2}{2g} = \frac{(5)^2}{2\times9.8} = \frac{25}{2\times9.8}$$

Work done by gravity (W) = mgh cos θ

$$W = 0.1 \times 9.8 \times \frac{25}{2\times9.8}\cos180° \quad (\because \theta = 180°)$$

$$\therefore W = -0.1 \times \frac{25}{2} = -1.25J$$

18. An engine pumps up 100 kg of water through a height of 10m in 5s. Given that the efficiency of engine is 60%. If g = 10 ms^{-2}, the power of the engine is–

(a) 3.3 kW (b) 0.33 kW
(c) 0.033 kW (d) 33 kW

JIPMER -2014
BCECE-2008
UP CPMT-2006

Ans. (a) : Given,

m = 100 kg, h = 10 m, t = 5 sec, g = 10 ms^{-2}

Efficiency (η) = 60% = 0.6

Work done = mgh

$$W = 100 \times 10 \times 10$$
$$= 10000 \text{ J}$$

$$\text{Effective power} = \frac{\text{Work}}{\text{Time}}$$
$$= \frac{10000}{5}$$
$$= 2000 \text{ watt}$$

Effective power = Efficiency × Total power

$$\text{Total power} = \frac{\text{Effective power}}{\text{Efficiency}}$$

$$\text{Total power} = \frac{2000}{0.6}$$
$$= 3333 \text{ watt} = 3.33 \text{ kW}$$

19. A force $\vec{F} = (5\hat{i} + 4\hat{j})$N acts on a body and produces a displacement $\vec{S} = (6\hat{i} - 5\hat{j} + 3\hat{k})$m. The work done by the force is

(a) 10 J (b) 20 J
(c) 30 J (d) 40 J

AP EAMCET (17.09.2020) Shift-II
Manipal UGET-2013

Ans. (a): Given that-

$$\vec{F} = (5\hat{i} + 4\hat{j})N \quad \text{or } \vec{F} = (5\hat{i} + 4\hat{j} + 0\hat{k})N$$

$$\vec{S} = (6\hat{i} - 5\hat{j} + 3\hat{k})m.$$

Work done, $W = \vec{F}.\vec{S}$

$$W = \left(5\hat{i} + 4\hat{j} + 0\hat{k}\right).\left(6\hat{i} - 5\hat{j} + 3\hat{k}\right)$$

$$W = 30 - 20 + 0$$
$$W = 10 \text{ J}$$

20. The heart of a man pumps 5 L of blood through the arteries per minute at a pressure of 150 mm of mercury. If the density of mercury be 13.6 × 10^3 kg /m^3 and g = 10m/s^2, then the power of heart in watt is

(a) 1.70 (b) 2.35
(c) 3.0 (d) 1.50

CG PET- 2021
AIPMT- 2015

Ans. (a) : Given that,

Density of mercury $\left(\rho_{Hg}\right) = 13.6x10^3 kg/m^3$

$$g = 10 m/s^2$$

$V = 5 \text{ x } 10^{-3}$ kg/m^3

h = 150mm of Hg = 150×10^{-3} m

@apna_pdf

We know that,

$$\text{Power (P)} = \frac{\text{work done}}{\text{time}}$$

$$\text{Power (P)} = \frac{\text{Pressure} \times \text{volume}}{\text{time}} = \frac{\rho gh \times V}{t}$$

$$= \frac{13.6\times10^3 \times 10 \times 150 \times 10^{-3} \times 5 \times 10^{-3}}{60}$$

$$= \frac{102}{60} = 1.70 \text{ watt}$$

21. The work done on the particle of mass M by a force, is given as

$$k\left[\frac{x}{(x^2+y^2)^{3/2}}\hat{i} + \frac{y}{(x^2+y^2)^{3/2}}\hat{j}\right]$$

(k being constant of appropriate dimensions). When the particle is taken from the point (a, 0) to the point (0, a) along a circular path of radius a about the origin in the x-y plane is

(a) $2k\frac{\pi}{a}$ (b) $k\frac{\pi}{a}$

(c) $k\frac{\pi}{2a}$ (d) 0

AP EAMCET (20.04.2019) Shift-II

CG PET -2016

Ans. (d): Given,

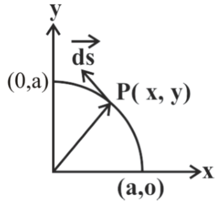
$$F = k\left[\frac{x}{\left(x^2+y^2\right)^{3/2}}\hat{i} + \frac{y}{\left(x^2+y^2\right)^{3/2}}\hat{j}\right]$$

Small distance travelled by the particle in the direction

$d\vec{r} = dx\hat{i} + dy\hat{j}$

Small work done, dw = $\vec{F}.d\vec{r}$

$$dw = k\left[\frac{xdx}{\left(x^2+y^2\right)^{3/2}} + \frac{ydy}{\left(x^2+y^2\right)^{3/2}}\right]$$



Let, $x^2 + y^2 = t^2$

2xdx = 2tdt At point (a, 0) t = a

2ydy = 2tdt At point (0, a) t = a

$$\int dW = k\left[\frac{tdt}{t^3} + \frac{tdt}{t^3}\right]$$

$$= 2k\int_a^a\left[\frac{1}{t^2}dt\right]$$

$$= 2k\int_a^a \frac{1}{t^2}dt = 2k\left[\frac{-1}{t}\right]_a^a = -2k\left(\frac{1}{a}-\frac{1}{a}\right)$$

W = 0

22. An elevator can carry a maximum load of 1000 kg is moving up with a constant speed of 2 m/s. The frictional force opposing the motion is 2000 N. The minimum power delivered by the motor to the elevator is:

(Assuming g=10 m/s^2)

(a) 18 kW (b) 24 kW

(c) 20 kW (d) 26 kW

NEET - 2022

TS EAMCET 29.09.2020, Shift-II

Ans. (b) : Given,

Maximum load that can carry by elevator,

m = 1000 kg, g = 10 m/s^2

Speed (v) = 2m/s.

Friction force (f) = 2000 N

Force acting downward,

F = mg + f

F = 1000×10+2000

= 10000 + 2000

F = 12000 N

Power delivered (P) = Force × Velocity

= 12000×2

= 24,000 Watts

P = 24 kW

23. A force F = 3x^2 + 2x + 1 acts on a body in the x – direction. The work done by this force during a displacement from x = –1 to +1 is

(a) 2 units (b) 4 units

(c) 6 units (d) 8 units

MHT-CET 2020

J&K-CET-2019

Ans. (b) : Given,

F = 3x^2 + 2x + 1 and displacement from x = –1 to 1

$$\because \text{work done} = \int_{x_1}^{x_2} F.dx$$

$$= \int_{-1}^{1}\left(3x^2+2x+1\right)dx$$

$$= \left[3\cdot\frac{x^3}{3} + 2\cdot\frac{x^2}{2} + x\right]_{-1}^{1}$$

$$= \left[x^3 + x^2 + x\right]_{-1}^{1}$$

$$= \left(1^3+1^2+1\right) - \left[\left(-1\right)^3 + \left(-1\right)^2 + \left(-1\right)\right]$$

$$= 3 + 1 = 4 \text{unit}$$

24. A force of (5 + 3x) N acting on a body of mass 20 kg along the x-axis displaces it from x = 2 m to x = 6 m. The work done by the force is

(a) 20 J (b) 48 J

(c) 68 J (d) 86 J

AP EAMCET (21.04.2019) Shift-II

UPSEE - 2009

@apna_pdf

Ans. (c): Given, Force (F) = (5 + 3x) N

x = 2m to 6 m

Now, Work done (W) = $\int F\,dx$

$$= \int_2^6 (5+3x)\,dx$$

$$= \left[5x + \frac{3x^2}{2}\right]_2^6$$

$$= 5\times 6 + \frac{3\times 36}{2} - 5\times 2 - \frac{3\times 4}{2}$$

$$= 30 + 54 - 10 - 6$$

$$= 84 - 16$$

W = 68 J

25. A gardener pushes a lawn roller through a distance 20 m. If he applies a force of 20 kg-wt in a direction inclined at 60º to the ground, the work done by him is

(a) 1960 J (b) 196 J

(c) 1.96 J (d) 196 J

JCECE-2014

J&K CET- 2011

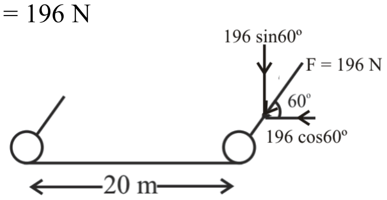
Ans. (a) : Given, d = 20 m, θ = 60°

Force applied by the gardener to push the lawn roller

F = 20 kg - wt

= 20 × 9.8 $(\therefore 1 \text{ kg-wt} = 9.8\text{N})$

= 196 N



Force applied by the gardener is constant, we can use the formula

∴ W = F.d cos θ

W = 196 × 20 × cos 60º

$$W = 196 \times 20 \times \frac{1}{2}$$

W = 1960 J

The work done by gardener is pushing the lawn roller is 1960 J

26. A block of mass 2kg is pulled at a constant speed with a taut rope along a frictionless plane that is inclined at 30^0. Then the work done by the tension in the rope in pulling it a distance 4m along the inclined plane in joule is– (acceleration due to gravity = 10 m s^{-2})

(a) 40 (b) 20

(c) 68 (d) 136

AP EAMCET-08.07.2022, Shift-I

Ans. (a) : Given, mass (m) = 2 kg, angle (θ) = 30º, distance (d) = 4 m

Now, Work done (W) = F.d

W= mgsinθ.d

W= 2×10 sin 30º×4

$$W = 2\times 10 \times \frac{1}{2}\times 4$$

W = 40J

27. If the momentum of a body is doubled, the kinetic energy becomes

(a) doubled (b) halved

(c) four times (d) three times

TS EAMCET 30.07.2022, Shift-I

Ans. (c) : Let,

mass of body, m

velocity, v

kinetic energy, (KE) = $\frac{1}{2}mv^2$

$$= \frac{1}{2}\frac{m^2v^2}{m}$$

$$(KE) = \frac{1}{2}\frac{p^2}{m} \quad \ldots(i) \quad [\because \text{ momentum }, p = mv]$$

According to question,

$p_1 = 2p$

Now,

$$(KE)_1 = \frac{1}{2}\times\frac{p_1^2}{m}$$

$$= \frac{1}{2}\times\frac{4p^2}{m} = \frac{1}{2}\times\frac{p^2}{m}\times 4$$

$(KE)_1 = (4KE)$

Hence, momentum of a body is doubled, the kinetics energy becomes four times.

28. A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is.

(a) 16 J (b) 8 J

(c) 32 J (d) 24 J

CG PET-22.05.2022

Ans. (b) : Given that,

k = 800 N/m

$x_1 = 5 \text{ cm} = 5\times 10^{-2}$m

$x_2 = 15 \text{ cm} = 15\times 10^{-2}$ m

$$\text{Work done } (W) = \frac{1}{2}k\left(x_2^2 - x_1^2\right)$$

$$W = \frac{1}{2}\times 800\times\left[\left(15\times 10^{-2}\right)^2 - \left(5\times 10^{-2}\right)^2\right]$$

$$W = \frac{1}{2}\times 800\times\left[225\times 10^{-4} - 25\times 10^{-4}\right]$$

$$W = \frac{1}{2}\times 800\times 200\times 10^{-4}$$

$$W = 8\times 10^4\times 10^{-4}$$

W = 8 J

29. The ball initially has a velocity of 5 m s^{-1} in the positive x- direction and some time later has a velocity of 7m s^{-1} in the positive y-direction. If the work done by the ball is 48 joule, then the mass of the ball in kg is

(a) 2.5 (b) 6.5

(c) 4 (d) 2

AP EAMCET-11.07.2022, Shift-I

@apna_pdf

Ans. (c) : Given, $\vec{u}_x = 5\hat{i}\,m/s$, $\vec{u}_y = 0\hat{j}\,m/s$

$u = 5$ m/sec

$\vec{v}_y = 7\hat{j}\,m/s$, $\vec{v}_x = 0\hat{i}\,m/s$

$v = 7$ m/s

$W = 48$ J

By work energy theorem

Changing kinetic energy = work done

$\because \ \Delta KE = W$

$$\frac{1}{2}m\left(v_f^{\,2} - u_i^{\,2}\right) = W$$

$$\frac{1}{2}m\left(7^2 - 5^2\right) = 48$$

$$m = \frac{2 \times 48}{24}$$

$m = 4$ kg

30. A 1 kg box placed at the origin starts sliding along x-axis under the action of a force $\vec{F} = F\hat{i}$. Its acceleration as a function of x is given by $a(x) = \beta.x$ where $\beta = 5s^{-2}$. The work done by $\vec{F}$ is moving the box from x = 2 cm to x = 5 cm in joule is–

(a) 52.5×10^{-4} (b) 105.5×10^{-4}

(c) 17.0×10^{-4} (d) 34.0×10^{-4}

AP EAMCET-08.07.2022, Shift-I

Ans. (a) : Given,

$m = 1$ kg, $\vec{F} = F\hat{i}$

$a(x) = \beta.x$, $x_1 = 2 \times 10^{-2}$ m

$x_2 = 5 \times 10^{-2}$ m

we know that,

$$a = v\frac{dv}{dx}$$

then,

$$v\frac{dv}{dx} = \beta x$$

$$\int_0^v v\,dv = \beta \int_{2\times10^{-2}}^{5\times10^{-2}} x\,dx$$

$$\left[\frac{v^2}{2}\right]_0^v = \beta\left[\frac{x^2}{2}\right]_{2\times10^{-2}}^{5\times10^{-2}} = \frac{\beta}{2}[25-4]\times10^{-4}$$

$$\frac{v^2}{2} == 21 \times \frac{\beta}{2} \times 10^{-4} \Rightarrow v^2 = 21 \times \beta \times 10^{-4}$$

$v^2 = 21 \times 5 \times 10^{-4}$ $(\beta = 5s^{-2})$

$= 105 \times 10^{-4}$

work done = change in K.E.

$\because$ work done $= \frac{1}{2} \times 1 \times 105 \times 10^{-4}$ (m = 1kg)

$W = 52.5 \times 10^{-4}$ J

31. Consider a force F = Kx³. Which acts on a particle at rest. The work done by the force for displacement of 2m is.
($K = 2\ Nm^{-3}$)

(a) 10J (b) 4J

(c) 100J (d) 8J

AP EAMCET-05.07.2022, Shift-II

Ans. (d) : Given, initially at rest $(x_1) = 0$

displaced $(x_2) = 2m$ and $F = Kx^3$

Work done is given by

$$W = \int_{x_1}^{x_2} F.dx$$

$$= \int_0^2 Kx^3 dx$$

$$= K\left[\frac{x^4}{4}\right]_0^2 = \frac{K}{4}[16-0]$$

$$= \frac{2}{4} \times 16 = 8\ J$$

32. An object of mass 20kg. is displayed by $x = 5t^2$ m (here t is time) by the application of a force. Then the ratio of the work done in times 3 s and 5 s is–

(a) $\frac{2}{3}$ (b) $\frac{4}{9}$

(c) $\frac{3}{5}$ (d) $\frac{9}{25}$

AP EAMCET-07.07.2022, Shift-II

Ans. (d) : Given, mass (m) = 20 kg, $x = 5t^2$

$t_1 = 3$ sec, $t_2 = 5$ sec

We know that,

$W = \vec{F}.\vec{x}$

where x is displacement

$W = ma.x$ …(i)

$x = 5t^2$

Differentiate w.r.t. t

$$\frac{dx}{dt} = 10\ t$$

Again differentiate w.r.t. t

$$\frac{d^2x}{dt^2} = 10 = a$$

Putting the value of m, a, and x in equation (i)

The work done is 3 sec ($t_1 = 3$ sec)

$W_1 = 20 \times 10 \times 5 \times t_1^2$

$W_1 = 20 \times 10 \times 5 \times 3^2 = 9000$

The work done in 5 sec ($t_2 = 5$ sec)

$W_2 = 20 \times 10 \times 5 \times t_2^2$

$W_2 = 20 \times 10 \times 5 \times 5^2 = 25000$

The ratio work done in W_1 and W_2 is-

$$\frac{W_1}{W_2} = \frac{9000}{25000} = \frac{9}{25}$$

@apna_pdf

33. A circular ring of mass 10 kg and radius 1 m is rotating at 210 revolutions in a minute. It is brought to stop in 2s. The required average power is

(a) 980 W (b) 1210 W

(c) 1340 W (d) 1580 W

AP EAPCET-12.07.2022, Shift-II

Ans. (b): Given, mass (m) = 10 kg, time (t) = 2 sec

Radius of ring (r) = 1m.

N = 210 Revolution/min.

$$\omega = 2\pi N$$

$$= 2\times\frac{22}{7}\times\frac{210}{60}$$

$$= 22 \text{ rad/sec}$$

$$\tau = I\alpha$$

$$\tau = mr^2\alpha$$

$$\tau = 10\times(1)^2\frac{\omega}{t} \qquad (\alpha = \frac{\omega}{t})$$

$$= \frac{10\times 22}{2} = 110$$

$$P_{avg} = \frac{\tau.\omega}{t}$$

$$= \frac{110\times 22}{2}$$

$$P_{avg} = 1210 \text{ W}$$

34. A Block of mass 50 kg is pulled at a constant speed of 4 m s^{-1} across a horizontal floor by an applied force of 500 N directed 30^o above the horizontal. The rate at which the force does work on the block in watt is

(a) $\frac{2000}{\sqrt{3}}$ (b) $500\sqrt{3}$

(c) 1732 (d) 1864

AP EAMCET-05.07.2022, Shift-I

Ans. (c) : Given, mass of block (m) = 50 kg

speed (v) = 4 m/sec, force (F) = 500 N

angle (θ) = 30^o

The power associated with force $\vec{F}$ is, $P = \vec{F}.\vec{v}$

And

$$P = F\, v \cos\theta$$

$$P = (500 \text{ N}) \times (4.0 \text{ m/s}) \cos 30°$$

$$P = 2000\times\frac{\sqrt{3}}{2}$$

$$P = 1000\times 1.732$$

$$P = 1732$$

35. A particle of mass 500 gm is moving in a straight line with velocity v = bx$^{5/2}$. The work done by the net force during its displacement from x = 0 to x = 4 m is :

(Take b = 0.25 m$^{-3/2}$s^{-1})

(a) 2 J (b) 4 J

(c) 8 J (d) 16 J

JEE Main-29.06.2022, Shift-I

Ans. (d) : Given that,

$$\text{Mass (m)} = 500 \text{ gm} = \frac{1}{2}\text{kg}, \quad v = bx^{5/2}$$

$$b = 0.25\, m^{-3/2}s^{-1} = \frac{1}{4}m^{-3/2}s^{-1}$$

Then, $v = \frac{1}{4}x^{5/2}\, m^{-3/2}s^{-1}$

If $x = 0, \quad v_1 = 0$

If $x = 4, \quad v_2 = \frac{1}{4}(4\text{m})^{5/2}\, m^{-3/2}s^{-1}$

$$v_2 = \frac{1}{4}.\left(2^2\right)^{5/2} \text{m/s}$$

$$v_2 = 8 \text{ m/s}$$

∵ Work done (W) = Change in K.E.

$$= \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$= \frac{1}{2}\times\frac{1}{2}\times(8)^2 - \frac{1}{2}\times\frac{1}{2}\times 0$$

$$W = 16 \text{ J}$$

36. Sand is being dropped from a stationary dropper at a rate of 0.5 kgs^{-1} on a conveyor belt moving with a velocity of 5 ms^{-1}. The power needed to keep belt moving with the same velocity will be:

(a) 1.25 W (b) 2.5 W

(c) 6.25 W (d) 12. 5 W

JEE Main-27.07.2022, Shift-I

Ans. (d) : Mass of sand drops at a rate of 0.5 kg/s.

$$\frac{dm}{dt} = 0.5 \text{kg/s}$$

Velocity of conveyor belt (v) = 5m/s

Now

Force required to keep the ball moving,

$$F = \frac{d}{dt}(mv) = v\frac{dm}{dt} = 0.5\times 5 = 2.5 \text{ N}$$

Then,

Power delivered by the motor (P) = F.v

$$= 2.5\times 5$$

$$= 12.5 \text{ W}$$

37. Arrange the four graphs in descending order of total work done; where W$_1$, W$_2$, W$_3$ and W$_4$ are the work done corresponding to figure a, b, c and d respectively.

(A)

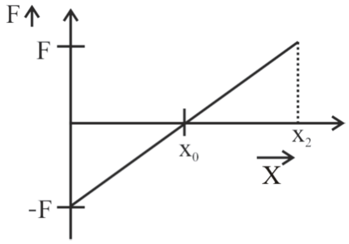
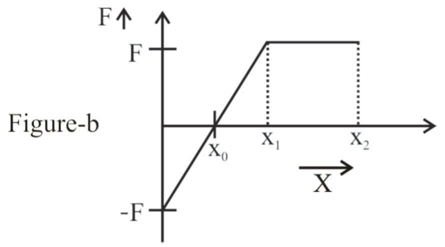


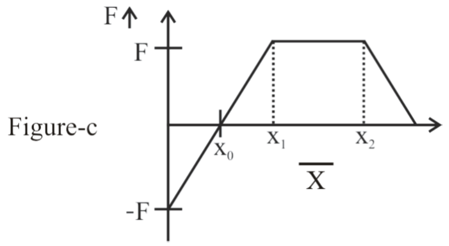
Figure-a

@apna_pdf

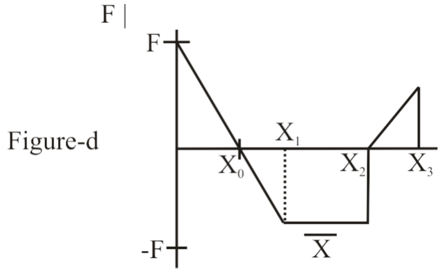
(B)



(C)



(D)



(a) $W_3>W_2>W_1>W_4$ (b) $W_3>W_2>W_4>W_1$
(c) $W_2>W_3>W_4>W_1$ (d) $W_2>W_3>W_1>W_4$

JEE Main-26.06.2022, Shift-II

Ans. (a) : From the graph,
Work done = Area under F – X curve.
Also, area below X-axis is negative & area above X-axis is positive.
From the given graph, it is clearly visible that,

$$A_3 > A_2 > A_1 > A_4$$

$$\therefore \; W_3 > W_2 > W_1 > W_4 \qquad \{\because W \propto A; A = \text{area}\}$$

38. A force on an object of mass 100g is $\left(10\hat{i}+5\hat{j}\right)$N. The position of that object at t = 2 s is $\left(a\hat{i}+b\hat{j}\right)$m after starting from rest. The value of $\frac{a}{b}$ will be _______.

JEE Main-25.06.2022, Shift-I

Ans. (2) : Given : m = 100g = 0.1 kg

$$\vec{F} = \left(10\hat{i}+5\hat{j}\right)\text{N}$$

$$\vec{s} = \left(a\hat{i}+b\hat{j}\right)\text{m}$$

$$t = 2\text{ s} \quad , \frac{a}{b} = ?$$

Now, $F_x = 10$ & $F_y = 5$

$$\because a = \frac{F}{m}$$

$$a_x = \frac{10}{0.1} \quad \& \quad a_y = \frac{5}{0.1}$$

$$a_x = 100\text{ m/s}^2 \quad \& \quad a_y = 50\text{ m/s}^2$$

At t = 2 s

$$\because s = ut + \frac{1}{2}at^2$$

$$\therefore s_x = 0 + \frac{1}{2}\times 100 \times 4 \quad \& \quad s_y = 0 + \frac{1}{2}\times 50\times 4$$

$$s_x = 200\text{m} \quad \& \quad s_y = 100\text{m}$$

$$\therefore \quad s = \left(200\hat{i}+100\hat{j}\right)\text{m} \qquad \text{.......(i)}$$

Comparing equation (i) with $s = \left(a\hat{i}+b\hat{j}\right)$m, we get

$$a = 200 \quad \& \quad b = 100\text{m}$$

$$\therefore \quad \frac{a}{b} = \frac{200}{100}$$

$$\frac{a}{b} = 2$$

39. A block of mass m = 2kg is pulled by a force F = 40N upwards through a height h = 2m. The work done by its weight is.

(a) –40 J (b) 60 J
(c) 80 J (d) –60 J

Assam CEE-31.07.2022

Ans. (a) : Given,
Mass (m) = 2kg,
Force (F) = 40N,
Height (h) = 2m
∴ Weight (w) = mg
w = 2 × 10 = 20 N

Work done by applied force (W_F) = Fh cos0°

$$W_F = 40\times2\times1 \quad [\because \cos 0° = 1]$$

$$W_F = 80\text{ J}$$

Similarly, work done by its weight

$$W_{mg} = w\times h\times \cos 180°$$
$$= 20\times2\times(-1) \quad [\because \cos 180° = -1]$$
$$= -40\text{ J}$$

40. A ball of mass 1 kg moves in a straight line with velocity $v = cx^{\alpha}$. where c = 1 (SI unit) and α is a constant. If the work done by the net force during its displacement from x = 0 to x = 4m is 128 Joule, then the α is

(a) 1 (b) $\frac{3}{2}$
(c) 2 (d) $\frac{1}{2}$

TS EAMCET 19.07.2022, Shift-I

Ans. (c) : Given
Mass of the body (m) = 1 kg, Velocity (v) = cx^{α}
Velocity of body at x = 0
$v_1 = 1 \times 0 = 0$
Velocity of body at x = 4
$v_2 = 1 \times (4)^{\alpha}$ m/s = $(4)^{\alpha}$ m/s

@apna_pdf

Work done = change in kinetic energy

$$128 = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$128 = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$$

$$128 = \frac{1}{2}\times 1\left[\left(4^{\alpha}\right)^2 - (0)^2\right]$$

$$128 = \frac{1}{2}\times (4)^{2\alpha}$$

$$256 = (4)^{2\alpha}$$

$$(4)^4 = (4)^{2\alpha}$$

On comparing the powers–

$2\alpha = 4$

$\alpha = 2$

41. The instantaneous power in terms of force F and instantaneous velocity v is

(a) $P = F.t$
(b) $P = F\,.\,v$
(c) $P = F\,.\,v^{-1}$
(d) $P = F\,.\,v^{-2}$
(e) $P = F\,.\,v.\,t^{-1}$

Kerala CEE 2021

Ans. (b) : We know that,

$$\text{Power}(P) = \frac{\text{Work done}(W)}{\text{Time}(t)}$$

$$P = \frac{F.s}{t} \qquad \left(\because v = \frac{s}{t}\right)$$

Where, P = Power
F = Force
s = displacement
t = time

∴ $P = F.v$

42. A stream of water flowing horizontally with a speed of 15 ms^{-1} gushes out of a tube of cross-sectional area 10^{-2} m^2 and hits a vertical wall nearby. The force exerted on the wall by the impact of water, assuming it does not rebound. is_____

(a) 2.25×10^3N
(b) 2.50×10^3N
(c) 3.0×10^3N
(d) 3.5×10^3N

AP EAMCET (Medical)-05.10.2021, Shift-I

Ans. (a) : Given,

Speed of water flowing horizontally (v) = 15 m/s

Cross sectional area (A) = 10^{-2} m^2

Density of water (ρ) = 10^3 kgm^{-3}

Mass of water flowing out per/sec = $\rho\times A\times v$

$= 10^3\times10^{-2}\times15$

$= 150$ kg/s

Now,

Force applied on the wall = momentum loss of water per/sec

$= 150$ kg/s × 15 m/s

$= 2250$ N

$= 2.25\times10^3$ N

43. When a light body and a heavy body have equal momenta. The kinetic energy is greater for _____

(a) The lighter body
(b) The heavy body
(c) Both are equal
(d) Can't be determined

AP EAMCET-05.10.2021, Shift-I

Ans. (a) : Though, the momenta of heavy body and light body are same. Therefore, the velocity of light is going to be greater than heavy body.

we know that,

$$\text{Kinetic energy }(KE) = \frac{1}{2}mv^2$$

Where, KE is proportional to the square of velocity. So, the lighter body will have greater kinetic energy.

44. If the engine of a train of mass 2.05 × 10^6 kg requires a duration of 7 minutes for changing its velocity from 5 m.s^{-1} to 25 m.s^{-1} find the power of the engine.

(a) 1.46×10^6 W
(b) 2.05×10^6 W
(c) 5×10^{-3} W
(d) 2.5×10^3 W

AP EAMCET-03.09.2021, Shift-II

Ans. (a) : Given,

Mass (m) = 2.05×10^6 kg,

Time (t) = 7min = 420 sec

Final velocity (v) = 25 m/s

Initial velocity (u) = 5 m/s

We know that, $v = u + at$

$$a = \frac{v-u}{t}$$

$$a = \frac{25-5}{420} = \frac{1}{21}\,m/s^2$$

Using equation of motion,

$$v^2 - u^2 = 2as$$

$$25^2 - 5^2 = 2\times\frac{1}{21}\times s$$

s = 6300 m

Also we know that

$$P = \frac{\text{Work done}}{\text{Time}}$$

$$P = \frac{F\times d}{t}$$

$$P = \frac{m\times a\times s}{t}$$

$$P = \frac{2.05\times10^6\times1\times6300}{21\times420}$$

$$P = \frac{12915\times10^6}{8820}$$

$P = 1.46\times10^6$ W

@apna_pdf

45. A force of 10 N acts on a mass of 20 kg which initially is at rest. Find the work done by the force during the first 3 seconds of motion.

(a) 12.5 J (b) 15.5 J

(c) 22.5 J (d) 42. 5 J

AP EAMCET-07.09.2021, Shift-I

Ans. (c) : Given,

Force (F)=10N

Time (t) = 3 second.

Mass (m) = 20kg

Force (F) =ma

ma = F

20×a=10N

$a = \frac{10}{20} = \frac{1}{2}\, m/s^2$

Work done (W)=F.d

In 3rd second (t=3 Second)

$s = \frac{1}{2} \times \frac{1}{2} \times (3)^2 = \frac{9}{4}\, m$

So displacement $s = \frac{9}{4}\, m$

∴ Work done (W) = F.s

$= 10 \times \frac{9}{4} = 22.5J$

46. A body of mass 3 kg is under a force, which causes a displacement in the body given by $s = \frac{t^3}{3}$ (in meters). Find the work done by the force in the first 2 seconds.

(a) 2 J (b) 3.8 J

(c) 5.2 J (d) 24 J

AP EAMCET-07.09.2021, Shift-I

Ans. (d) : Given,

Mass (m) = 3 kg

$s = \frac{t^3}{3}$

$\frac{ds}{dt} = \frac{3t^2}{3}$

$v = t^2$

$\Rightarrow ds = t^2 dt$

$\frac{dv}{dt} = 2t$

$a = 2t$

$\therefore$ Work done (W) = $\int_0^2 F ds = \int_0^2 mads = \int_0^2 mat^2 dt$

$W = \int_0^2 3 \times 2t \times t^2 dt = 6\int_0^2 t^3 dt$

$W = \frac{6}{4}[t^4]_0^2 = \frac{6}{4} \times (16 - 0)$

W= 24J

47. A body of mass 8 kg. under the action of a force, is displaced according to the equation $s = \frac{t^2}{4}$ m, where 't' is the time. Find the work done by the force in the first 4 seconds.

(a) 9 J (b) 16 J

(c) 6 J (d) 3 J

AP EAMCET-19.08.2021, Shift-I

Ans. (d) : Given, m = 8 kg, t = 4 second

Displacement (s) = $\frac{t^2}{4}$ m

$v = \frac{ds}{dt}$

$v = \frac{d}{dt} \cdot \left(\frac{t^2}{4}\right)$

$v = \frac{2t}{4} = \frac{t}{2}$

Now,

At t = 0 and velocity $v_1 = 0$

Then, kinetic energy $K_1 = 0$

at t = 4 sec

Then, velocity $(v_2) = \frac{4}{2} = 2\, m/s$

Kinetic energy, $K_2 = \frac{1}{2} m v_2^2 = \frac{1}{2} \times 8 \times (2)^2 = 16$

Work done = Changing in kinetic energy in K.E

$W = K_2 - K_1$

$= 16 - 0 = 16$ J

48. Match the following?

Column - I	Column-II
(a) F_{net}	**(i)** $\frac{dK}{dt}$
(b) F_{cons}	**(ii)** $\Delta U + \Delta K$
(c) $\sum W_{non-cons}$	**(iii)** $\frac{-dU}{dx}$
(d) Power	**(iv)** $\frac{dP}{dt}$

(a) (a – iv), (b – iii), (c – ii), (d – i)

(b) (a – iii), (b – ii), (c – ii), (d – ii)

(c) (a – ii), (b – i), (c –iv), (d – iii)

(d) (a – ii), (b – iii), (c – i), (d – iv)

AP EAMCET-06.09.2021, Shift-I

Ans. (a) : Correctly match

Column-I		Column-II
F_{net}	–	$\frac{dP}{dt}$
F_{cons}	–	$-\frac{dU}{dx}$
$\sum W_{non-cons}$	–	$\Delta U + \Delta K$
Power	–	$\frac{dK}{dt}$

@apna_pdf

49. An engine develops 20 kW of power. How much time will it take to lift a mass of 200 kg to a height of 40m? ($g = 10 m.s^{-2}$)

(a) 4s (b) 5s
(c) 8s (d) 10s

AP EAMCET-20.08.2021, Shift-II

Ans. (a) : Given,

Mass of lift (m) = 200 kg, Height (h) = 40 m,
$g = 10\ m/s^2$, Power (P) = 20 kW = 20×10^3 W

$$\text{Power (P)} = \frac{(m\cdot g\cdot h)}{t}$$

Or

$$t = \frac{m\cdot g\cdot h}{P} = \frac{200\times10\times40}{20\times10^3}$$

$$\boxed{t = 4\,\text{sec}}$$

50. A quarter horse power motor runs at a speed of 600 rpm. Assuming 60% efficiency, the work done by the motor in one rotation is ——

(a) 7.46 J (b) 74.6 J
(c) 111.9 J (d) 11.19 J

AP EAMCET-19.08.2021, Shift-II

Ans. (d):

600 revolution → 1 min
600 revolution → 60 sec

$$1\,\text{revolution} = \frac{60}{600}$$

$$1\,\text{revolution} = \frac{1}{10}\text{sec.}$$

$$P = \frac{E}{t}$$

$$P\times t = E$$

$$\text{Given, } P = \frac{HP}{4}$$

$$\frac{1}{4}HP\times\frac{1}{10}$$

$$= \frac{746}{4}\times\frac{1}{10}\times\frac{60}{100} = \frac{373\times3}{100}$$

W = 11.19 J

51. A lawn roller has been pushed through a distance of 80 m by applying a force of 50 kgwt in a direction inclined at 60° with the ground. Calculate the work done on the roller.

(a) 30×10^3J (b) 40×10^3J
(c) 10×10^3J (d) 20×10^3J

AP EAMCET-06.09.2021, Shift-II

Ans. (d) : Given:

Displacement (x) = 80m
Force (F) = 50kgwt = 50×10 = 500 N
Angle (θ) = 60^o

$$W = Fd\cos\theta$$

$$W = 500\times80\cos60^o$$

$$W = 500\times80\times\frac{1}{2}$$

$$W = 500\times40$$

$$W = 20\times10^3 J$$

52. Which of the following is not a correct statement?

(a) Work done by conservative force is equal to negative change in potential energy
(b) Total energy of system is always conserved
(c) Work done by non-conservative force in a closed path is equal to zero
(d) In stable equilibrium, the potential energy is minimum

TS EAMCET 05.08.2021, Shift-I

Ans. (c) : If the work done by that force on a particle that moves between two points depends on the path taken between those points.

Frictional and viscous forces are the examples of non-conservative forces. In case of such forces, if a particle moves from A to B and then B to A, the work done around the closed path is not zero, But the particle itself loses its kinetic energy along both paths. Thus for non-conservative force,

$$\oint \vec{F}.d\vec{r} = W_{(A\to B)} + W_{(B\to A)} \neq 0 \qquad ...(i)$$

For example, if we push a block over a rough table between any two points by various paths, the distance travelled varies and accordingly the work done by the frictional force and hence, the work done depends on the path. Hence, we cannot define a potential energy like function for non-conservative force.

53. A constant force of 5 N accelerates a stationary particle of mass 500 gm through a displacement of 5 m. The average power delivered is

(a) 6.25 W (b) 25 W
(c) 62.5 W (d) 50 W

TS EAMCET 05.08.2021, Shift-I

Ans. (b): Given,

Force, F = 5N, mass of stationary particle = 500 gm
Displacement (s) = 5m

$$\therefore \quad F = ma$$

$$5 = \frac{500}{1000}a$$

$$a = 10\ m/sec^2$$

We know that equation of second law of motion,

$$s = ut + \frac{1}{2}at^2$$

$$5 = \frac{1}{2}\times10t^2 \qquad [\because \text{Initial velocity, } u = 0]$$

$$5 = 5t^2$$

$$t = 1\ \text{sec}$$

Then, the average power delivered–

$$P = \frac{W}{t} = \frac{F.s}{t}$$

$$P = \frac{5\times5}{1}$$

$$= 25\ \text{Watt}$$

54. Which of the following statement is incorrect ?

(a) Conservation laws have deep connection with symmetries of nature
(b) Weak nuclear force is weakest among all fundamental forces of nature

@apna_pdf

(c) A conservation law is a hypothesis based on observations and experiments

(d) In a nuclear process mass gets converted to energy or vice versa

TS EAMCET 04.08.2021, Shift-I

Ans. (b) : Gravitational force is weakest of all fundamental forces. Gravitational force is the attraction between two masses.

Electromagnetic force is the force between two charged particles or two poles of a magnet. It is stronger than Gravitational force. Weak nuclear force is the weak force of attraction between the subatomic particles of the nucleus of an atom. Though the name suggests that it is weak, it is stronger than electromagnetic. Strong nuclear force is the stronger version of nuclear force. It is the strongest force in nature.

55. A force acts on a body of mass 15 kg, initially at rest. If the instantaneous power due to the force at the end of the third second is 5 W then the instantaneous power (in W) at the end of the fourth second will be

(a) 6.33 (b) 6.67

(c) 6.29 (d) 6.94

TS EAMCET 06.08.2021, Shift-II

Ans. (b) : Given,

$m = 15$ kg, $t = 3$ sec, $P = 5$ W

We know that,

$$P = F\cdot v$$

$$P = F\cdot(at) \qquad [\because v = at]$$

$$P = F\cdot\left(\frac{F}{m}\right)\cdot t \qquad \left[\because a = \frac{F}{m}\right]$$

$$P = \frac{F^2}{m}\cdot t$$

$$F^2 = \frac{Pm}{t}$$

$$F^2 = \frac{5\times15}{3}$$

$$F = \sqrt{25}$$

$$\boxed{F = 5N}$$

$$\because \quad v' = \frac{F}{m}\cdot t$$

$$= \frac{5}{15}\times4 = \frac{20}{15}$$

$$v' = \frac{4}{3}\,m/s$$

Now, Power at the end of 4th second–

$$P' = F\cdot v'$$

$$= 5\times\frac{4}{3} = \frac{20}{3}$$

$$\boxed{P' = 6.67\ W}$$

56. A horizontal force $\vec{F} = (g - x^2)\hat{i}$ N acts on a wooden block resting on a horizontal smooth surface. The work done to move the block from x = 0 to x = 3 m (in Joule) is (use g = 10 m/s^2):

(a) 24 (b) 35

(c) 30 (d) 21

TS EAMCET 06.08.2021, Shift-I

Ans. (d) : Given,

$g = 10$ m/s^2

$\vec{F} = (g - x^2)\hat{i}$ N

Work done to move the block from x = 0 to x = 3 m

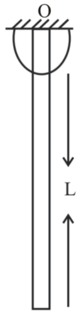
$$W = \int_{x_1}^{x_2} F dx = \int_0^3 (g - x^2)dx$$

$$W = \int_0^3 10dx - \int_0^3 x^2dx = 10[x]_0^3 - \left[\frac{x^3}{3}\right]_0^3$$

$$= 10\times3 - \frac{27}{3} = 30 - 9$$

$W = 21$ J

57. A rod of length L can rotate about end O. What is the work done if the rod is rotated by 180°.

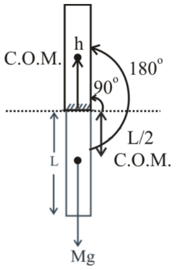


(a) MgL (b) $\frac{MgL}{2}$

(c) $\frac{3}{4}$MgL (d) $\frac{1}{4}$MgL

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (a) : $h = \frac{L}{2}\sin 90^\circ = \frac{L}{2}$



$$\text{Work done} = Mg\left(\frac{L}{2} + h\right)$$

$$= Mg\left(\frac{L}{2} + \frac{L}{2}\right)$$

$$= Mg\,L$$

@apna_pdf

58. A uniform thin rod of length L, mass m is lying on a smooth horizontal table. A horizontal impulse P is suddenly applied perpendicular to the rod at one end. The total energy of the rod after the impulse is

(a) $\frac{P^2}{M}$ (b) $\frac{7P^2}{8M}$

(c) $\frac{13P^2}{2M}$ (d) $\frac{2P^2}{M}$

WB JEE 2021

Ans. (c) : The given impulse acts as both linear and angular impulse.

Linear impulse $P = Mv_{cm} \Rightarrow v_{cm} = \frac{P}{M}$

Angular impulse $= P \times L = I_{cm}.\omega$

$$I_{cm} = \frac{ML^2}{12}$$

$$\text{Kinetic energy} = \frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$$

$$= \frac{1}{2}\left[M \times \left(\frac{P}{M}\right)^2 + I_{cm}\left(\frac{PL}{I_{cm}}\right)^2\right]$$

$$\text{Kinetic energy} = \frac{1}{2}\left[\frac{P^2}{M} + \frac{12 \times P^2L^2}{ML^2}\right]$$

$$\text{Kinetic energy} = \frac{1}{2}\left(\frac{P^2}{M} + \frac{12P^2}{M}\right)$$

$$\text{Kinetic energy} = \frac{13}{2}\left(\frac{P^2}{M}\right)$$

59. A thief stole a box full of valuable articles of weight 'W' and while carrying it on his head jumped down from a wall of height 'h' from the ground. Just before he reaches the ground, he experiences a load of ……… .

(a) 0 (b) $\frac{W}{2}$

(c) W (d) 2W

AP EAMCET-25.09.2020, Shift-I

Ans. (a) : He jumped down a wall of height 'h' from ground before reached the ground he experienced a load of 'zero' because of free fall.

60. If a force $\vec{F} = \hat{i} - 2\hat{j} - 4\hat{k}$ acting on a particle displaces it from (1, 1, 1) to (2, –1, 0), then the work done by the force (in units of work) is

(a) 2 (b) 1

(c) 5 (d) 4

(e) 9

Kerala CEE 2020

Ans. (e): Given, $\vec{F} = \hat{i} - 2\hat{j} - 4\hat{k}$, $\vec{r}_1 = \hat{i} + \hat{j} + \hat{k}$

$$\vec{r}_2 = 2\hat{i} - \hat{j} + 0\hat{k}$$

displacement vector $(\vec{r}) = \vec{r}_2 - \vec{r}_1$

$$\vec{r} = \left(2\hat{i} - \hat{j}\right) - \left(\hat{i} + \hat{j} + \hat{k}\right)$$

$$\vec{r} = (2-1)\hat{i} + (-1-1)\hat{j} + (0-1)\hat{k}$$

$$\vec{r} = \hat{i} - 2\hat{j} - \hat{k}$$

We know that,

Work done (W)= $\vec{F}.\vec{r}$

$$= (\hat{i} - 2\hat{j} - 4\hat{k})\,(\hat{i} - 2\hat{j} - \hat{k})$$

$$= 1 + 4 + 4 = 9$$

61. A force of 20 N acts on a body and displaces it through 5 m along a direction inclined at 60° to the direction of the force. Then the work done is equal to _____

(a) 50 J (b) 200 J

(c) $50\sqrt{3}$ J (d) $\frac{50}{\sqrt{3}}$ J

AP EAMCET-25.09.2020, Shift-II

Ans. (a) : Given, force (F) = 20 N, Angle (θ) = 60°

s = 5 m

Work done = F s. cos θ

$= 20 \times 5 \times \cos 60^\circ$

$= 100 \times \frac{1}{2}$

Work done = 50 J

62. $\left(60\hat{i} + 15\hat{j} - 3\hat{k}\right)$N force produces a velocity $\left(2\hat{i} - 4\hat{j} + 5\hat{k}\right)$in a particle. The value of power at that time will be ————

(a) 45 W (b) 95 W

(c) 75 W (d) 100 W

AP EAMCET-07.10.2020, Shift-I

Ans. (a) : Given, $\vec{F} = 60\hat{i} + 15\hat{j} - 3\hat{k}$,

$$\vec{v} = 2\hat{i} - 4\hat{j} + 5\hat{k}$$

We know that

$P = \vec{F}.\vec{v}$

$$= \left(60\hat{i} + 15\hat{j} - 3\hat{k}\right).\left(2\hat{i} - 4\hat{j} + 5\hat{k}\right) = 120 - 60 - 15$$

P = 45 W

63. Brakes stop a train in a certain distance x. If the force of these brakes is reduced to one fourth of its original force, the train needs ——– the original distance x to stop.

(a) Double (b) Half

(c) Four Times (d) Same

AP EAMCET-07.10.2020, Shift-I

Ans. (c) : Since force is proportional to the acceleration for a given body, $F \propto a$ ….(i)

From Newton's law of motion,

$v^2 = u^2 + 2as$

Given, v = 0

Let, u is constant

$a \propto \frac{1}{s}$ ….(ii)

From equation (i) and (ii), we get

$$F \propto \frac{1}{s}$$

Fs = k (constant)

@apna_pdf

So,

$F_1s_1 = F_2s_2$

according to question–

$F_1 = F$

and $F_2 = \frac{F}{4}$

Now, $F \times x = \frac{F}{4}s_2$

$x = \frac{s_2}{4}$

or $s_2 = 4x$

∵ The train needs four times of the original distance x to stop.

64. The force acting on the block is $10\sqrt{2}$ N with an angle 135°. Calculate the work done when the displacement is $\Delta x = 5$m

(a) $25\sqrt{2}$ J (b) $50\sqrt{2}$ J

(c) –50 J (d) – 40J

TS EAMCET 29.09.2020, Shift-I

Ans. (c) :

Work done (W) = $F\Delta x$

$= -P\cos135^\circ \times \Delta x = -10\sqrt{2}\times\frac{1}{\sqrt{2}}\times 5$

Work done = – 50 J

65. Out of the fundamental forces in nature, maximum and minimum range is respectively for

(a) electromagnetic force, gravitational force

(b) strong nuclear force, electromagnetic force

(c) gravitational force, weak nuclear force

(d) gravitational force, electromagnetic force

MHT-CET 2020

Ans. (c) : The forces without which, all matter in the world will fall apart, are called fundamental forces or universal forces.

There are four universal forces-

- **Gravitational forces:-** This force is the weakest out of the four but has infinitely long-range.
- **Strong nuclear force:-** It is the strongest attractive force out of the four.
- **Electromagnetic force:-** This acts between charged particles like negatively charged electron or positively charged proton. The greater charge, the greater force.
- **Weak Nuclear forces:-** It has very short range and it is weakest force in nature and responsible for radioactive decay.

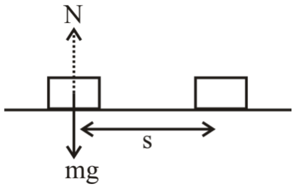
66. A block of mass 'm', kept on a horizontal surface, is moved through a distance s by applying a horizontal force (F) to it. What is the work done by the normal reaction ?

(a) $\frac{F}{s}$ (b) Zero

(c) Fs (d) $\frac{s}{F}$

MHT-CET 2020

Ans. (b) :



$W = N.s\cos\theta$

Angle between the normal reaction N and the displacement s is 90°. As cos90° = 0. Hence, the work done will be zero.

67. A Diwali cracker release 25 gram gas per second, with a speed of 400 ms^{-1} after explosion. The force exerted by gas on the cracker is

(a) 16 newton (b) 100 dyne

(c) 10,000 dyne (d) 10 newton

MHT-CET 2020

Ans. (d) : Given,

Rate of mass release $\left(\dot{m}\right) = 25$ g/s $= 25\times10^{-3}$ kg/s

$v = 400$ m/s

We know that,

F = rate of change of momentum = $\dot{m}v$

$= 25\times10^{-3}\times400$

$= 10$ N

68. A body of mass 'm' begins to move under the action of time dependent force $\vec{F} = (t\hat{i} + 2t^2\hat{j})$N where $\hat{i}$ and $\hat{j}$ are unit vectors along X and Y axis respectively. The power developed by the force in watt at time t is

(a) $\left(\frac{t^2}{3m}+\frac{3t^4}{4m}\right)$ (b) $\left(\frac{t^3}{m}+\frac{4t^5}{2m}\right)$

(c) $\left(\frac{t^2}{2m}+\frac{3t^4}{5m}\right)$ (d) $\left(\frac{t^3}{2m}+\frac{4t^5}{3m}\right)$

MHT-CET 2020

Ans. (d) : Given that, $\vec{F} = (t\hat{i}+2t^2\hat{j})$ N

$\therefore$ acceleration $\vec{a} = \frac{\vec{F}}{m} = \frac{1}{m}(t\hat{i}+2t^2\hat{j})$ m/s^2

And, $\vec{a} = \frac{d\vec{v}}{dt}$

$\therefore \quad d\vec{v} = \vec{a}\,dt$

$\therefore \quad \vec{v} = \int\vec{a}\,dt = \int\frac{1}{m}(t\hat{i}+2t^2\hat{j})\,dt$

$= \frac{1}{m}\left(\frac{t^2}{2}\hat{i}+\frac{2t^3}{3}\hat{j}\right)$

We know,

$\text{Power}\,(P) = \vec{F}.\vec{v} = (t\hat{i}+2t^2\hat{j}).\frac{1}{m}\left(\frac{t^2}{2}\hat{i}+\frac{2t^3}{3}\hat{j}\right)$

$= \frac{1}{m}\left(\frac{t^3}{2}+\frac{4}{3}t^5\right) = \left(\frac{t^3}{2m}+\frac{4t^5}{3m}\right)$

@apna_pdf

69. What is the amount of work done by a person when (i) he holds a mass of 2 kg for 5 second and (ii) he lifts the same mass through 1 meter to keep it on the top of a table? ($g = 9.8\ m/s^2$)

(a) 4.9 J and zero (b) zero and 4.9 J
(c) zero and 19.6 J (d) 19.6 J and zero

MHT-CET 2020

Ans. (c) : Given that,

$m = 2$ kg, $h = 1$ m, $g = 9.8\ m/s^2$

In the first case, there is no displacement. Hence, work done is zero.

In the second case, work done

$W = mgh = 2 \times 9.8 \times 1 = 19.6$ J

70. Work done in sliding a 1 kg block up a rough inclined plane of height 5 m is 100 J. Work done against the friction is ($g = 10 m/s^2$)

(a) 75 J (b) 25 J
(c) 50 J (d) 100 J

MHT-CET 2020

Ans. (c) : Given that,

$m = 1$ kg, $h = 5$ m, $g = 10\ m/s^2$

Total work done $W = W_1+W_2$

Where W_1 = work done against gravity

And W_2 = work done against friction

$W = 100$ J,

$W_1 = mgh = 1 \times 10 \times 5 = 50$ J

$\therefore$ $W_2 = W - W_1 = 100 - 50 = 50$ J

71. A cricket ball of mass 150 g moving with a velocity of 12 m/s is turned back with a velocity of 20 m/s on hitting the bat. The force of the blow lasts for 0.01 s. The force exerted on the ball by the bat is

(a) 480 N (b) 240 N
(c) 120 N (d) 360 N

MHT-CET 2020

Ans. (a) : Given that,

$m = 150$ g, $u = -12$ m/s, $v = 20$ m/s, $t = 0.01$ sec

We know,

$$\text{Force} = \frac{\text{Change in momentum}}{\text{time}} = \frac{mv - mu}{t}$$

$$F = \frac{0.150[20-(-12)]}{0.01}$$

$$= \frac{0.150[20+12]}{0.01}$$

$$= \frac{0.150 \times 32}{0.01} = 480\text{ N}$$

72. A mass $2\sqrt{3}$ kg is acted upon by two forces which are inclined to each other at 60^0 and each of magnitude 1N. The acceleration of that mass in SI system is

sin 30° = cos 60° = 0.5

(a) $0.9\ m/s^2$ (b) $0.7\ m/s^2$
(c) $0.5\ m/s^2$ (d) $0.3\ m/s^2$

MHT-CET 2020

Ans. (c) : Given that,

$m = 2\sqrt{3}$ kg, $F_1 = 1$ N, $F_2 = 1$N, $\theta = 60°$m

We know,

$$\text{Resultant } (F_R) = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$F_R = \sqrt{1+1+2\times1\times1\times\cos 60^0}$$

$$F_R = \sqrt{3}\text{ N}$$

Since, $F = ma$

$$\therefore \quad a = \frac{F_R}{m} = \frac{\sqrt{3}}{2\sqrt{3}} = \frac{1}{2} = 0.5\ m/s^2$$

73. A body of mass 5 kg is moving in a straight line. The relation between its displacement and time is $x = (t^3 - 2t - 10)$m. What is the force acting on it at the end of 5 second?

(a) 120 N (b) 80 N
(c) 150 N (d) 100 N

MHT-CET 2020

Ans. (c) : Given that, mass = 5kg, t = 5 sec

and $x = (t^3 - 2t - 10)$m ....(i)

Differentiating equation (i) w.r.to 't'

$$v = \frac{dx}{dt} = 3t^2 - 2 \quad ....(ii)$$

Again differentiating equation (ii) w.r.to 't'

$$a = \frac{d^2x}{dt^2} = 6t$$

$$a = \left(\frac{d^2x}{dt^2}\right)_{t=5sec} = 30$$

$\therefore$ $a = 30\ m/s^2$

We know,

$F = ma$

$F = 5 \times 30 = 150$ N

74. A vehicle accelerates from speed 'v' to '2v'. Work done during this is

(a) less than the work done in accelerating it from rest to v.
(b) four times as the work done in accelerating it from rest to v.
(c) same as the work done in accelerating it from rest to v.
(d) three times as work done in accelerating it from rest to v.

MHT-CET 2020

Ans. (d) : Work done = Change in K.E.

$$W = \Delta K.E. = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$$

When, vehicle accelerates from rest to v

$$W_i = \frac{1}{2}m\left(v^2 - 0^2\right)$$

$$W_i = \frac{1}{2}mv^2$$

When vehicle accelerates from v to 2v

i.e. $v_1 = v$, $v_2 = 2v$

@apna_pdf

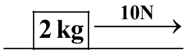
$$W_f = \frac{1}{2}m[(2v)^2 - v^2]$$

$$= \frac{1}{2}m(4V^2 - V^2) = \frac{3V^2 m}{2} = 3\left(\frac{1}{2}mV^2\right)$$

$$W_f = 3W_i$$

Therefore, when a vehicle accelerates from speed V to 2V, work done during this is three times as work done in accelerating it from rest to V.

75. The block starts from rest as shown in the figure. Find the work done by force of 10 N and friction in the time 0 to 4 s.
[Take, $g = 10\ m/s^2$]



$\mu = 0.2$

(a) 240 J, –96 J (b) 250 J, 96 J
(c) 240 J, 96 J (d) 250 J, –96 J

TS-EAMCET.11.09.2020, Shift-2

Ans. (a) : Given, mass of block (m) = 2 kg
Applied force (F) = 10 N
Frictional force (f) = μmg
$= 0.2 \times 2 \times 10 = 0.4 \times 10 = 4N$
Net Force = Applied force – Frictional force
= 10 – 4 = 6 N
Acceleration of block is -

$$a = \frac{F_{net}}{m} = \frac{6}{2} = 3m/s^2$$

Total distance covered in 4 sec.–

$$s = ut + \frac{1}{2}at^2 \qquad (\therefore \text{ Initial velocity, } u = 0)$$

$$s = 0 + \frac{1}{2} \times 3 \times (4)^2$$

$$s = \frac{1}{2} \times 3 \times 16$$

$$s = 24\ m$$

Now, work done by (F = 10N) applied force–
$W_1 = F.s\cos\theta$
$W_1 = 10 \times 24 \times \cos 0^o$
$W_1 = 240$ J
Work done by friction-
$W_2 = f.s\cos 180^o = -4 \times 24 = -96$ J

76. A force $F = \left(2\hat{i} + 4\hat{j}\right)$ N is applied on an object of mass M. What is the work done by this force in moving the object horizontally along the X-axis by 3 m?

(a) 2 J (b) 4 J
(c) 6 J (d) 8 J

TS-EAMCET-10.09.2020, Shift-2

Ans. (c) : Given, $\vec{F} = \left(2\hat{i} + 4\hat{j}\right)N$, $\vec{s} = \left(3\hat{i}\right)m$

Work done (W) = $\vec{F}.\vec{s}$

$$= \left(2\hat{i} + 4\hat{j}\right).3\hat{i} \qquad \left(\because \hat{i}.\hat{i} = 1 \text{ and } \hat{j}.\hat{i} = 0\right)$$

$= 6 + 0$
$W = 6$ J

77. When a body is acted upon by a resultant force, then the work done by the resultant force is equal to

(a) its initial kinetic energy
(b) its initial potential energy
(c) change in the kinetic energy
(d) change in the potential energy

TS-EAMCET-10.09.2020, Shift-1

Ans. (c) : According to work energy theorem, work done by net force acting on a body is equal to change in kinetic energy of the body.

$$W = (KE)_f - (KE)_i$$

Where, $(KE)_i$ and $(KE)_f$ are the initial and final kinetic energies of the body respectively.

78. An elevator of mass 500 kg is ascending upwards with a constant acceleration $a = 2m/s^2$. What is the work done by the tension in the elevator cable during its climb by 12 m? (Take, $g = 10\ m/s^2$)

(a) 36 kJ (b) 48 kJ
(c) 72 kJ (d) 100 kJ

TS-EAMCET-11.09.2020, Shift-1

Ans. (c) : Given, m = 500 kg, s = 12m, $a = 2ms^{-2}$
Let the tension in the cable be T.
The equation of motion for the lift is-
$T - mg = ma$
$T = m(g + a)$
$T = 500(10 + 2)$
$T = 6000$ N
Work done by the tension force is,
$W = T \times s$
$= 6000 \times 12 = 72000$J
$W = 72$ kJ

79. A force of 4 N acts on a 10 kg body initially at rest. Let W_1 is work done by force during $0 \le t \le 1$s. Likewise W_2 is the work done by force during $1s \le t \le 2s$, where t is time in second. The ratio $\frac{W_2}{W_1}$ is

(a) 1 (b) 2
(c) $\frac{1}{2}$ (d) 3

TS-EAMCET-11.09.2020, Shift-1

Ans. (d) : Given, m = 10 kg, F = 4 N
We know that,
Force, F = m.a

$$\frac{F}{m} = a$$

$$\frac{4}{10} = a \Rightarrow a = 0.4ms^{-2}$$

For $0 \le t \le 1$s, displacement s_1 is,

$$s_1 = ut_1 + \frac{1}{2}at_1^2$$

$$s_1 = 0 \times 1 + \frac{1}{2} \times 0.4 \times 1 = 0.2m$$

Work done $(W_1) = F \times s_1 = 4 \times 0.2 = 0.8$ J ....(i)

@apna_pdf

Now, for $1s \le t \le 2s$

$t_2 = 1s$

Velocity of the body after t_1, we get-

$v = u + at_1$

$v = 0 + 0.4 \times 1 = 0.4ms^{-1}$

Displacement s_2 is,

$$s_2 = vt_2 + \frac{1}{2}at_2^2$$

$$s_2 = 0.4\times1+\frac{1}{2}\times0.4\times1^2 = 0.6m$$

$W_2 = F.s_2$

$W_2 = 4 \times 0.6 = 2.4J$ ....(ii)

Dividing equation (ii) by (i), we get-

$$\frac{W_2}{W_1} = \frac{2.4}{0.8} = 3$$

80. A boy pushes a toy box 2.0 m along the floor by means of a force of 10 N directed downward at an angle of 60° to the horizontal. The work done by the boy is

(a) 6 J (b) 8 J

(c) 10 J (d) 12 J

BITSAT-2020

Ans. (c): Given,

$F = 10N$

$d = 2m$

$\theta = 60^o$

We know that,

$W = \vec{F}.\vec{d}$

$W = Fd\cos\theta$

$W = Fd\cos60°$

$W = 10 \times 2 \times \frac{1}{2}$, $\left\{\because \cos60^o = \frac{1}{2}\right\}$

$W = 10$ J

81. A man pushes the wall and fails to displace it. He does

(a) negative work

(b) positive but not maximum work

(c) no work at all

(d) maximum work

AP EAMCET (21.09.2020) Shift-II

Ans. (c): When a man pushes the wall but he failed to displace it. So, he does no work at all.

So, the displacement (s) = 0

$W = F.s$

$W = F \times 0$

$W = 0$

Hence, no work done at all.

82. An automatic gun fires 360 bullets per minute with a speed of 360 km/h. If each bullet weight 20 g, the power of the gun is

(a) 75 W (b) 150 W

(c) 300 W (d) 600 W

AP EAMCET (21.09.2020) Shift-I

Ans. (d) : Given,

Speed (v) = 360 km/h,

Mass (m) = 20g = 20×10^{-3}kg

$$v = 360 \times \frac{5}{18} = 100 \text{ m/s}$$

No. of bullets (n) = 360 /min

$$\text{Power} = \frac{\text{Total energy}}{\text{time}}$$

$$= \frac{n \times (\text{K.E}) \text{ of each bullet}}{\text{time}} = \frac{n\times\frac{1}{2}mv^2}{t}$$

$$= \frac{360 \times \frac{1}{2} \times (20 \times 10^{-3})(100)^2}{60}$$

$$= \frac{360\times10^5\times10^{-3}}{60} = 6\times100$$

$P = 600$ W

83. A force F = 20 + 10y acts on a particle in y-direction, where F is in Newton and y in meter. Work done by this force to move the particle from y = 0 to y = 1m is

(a) 5 J (b) 25 J

(c) 20 J (d) 30 J

NEET -2019

Ans. (b) : Given that,

$F = 20 + 10y$

Work done by variable force is

$$W = \int_{y_1}^{y_2} F.dy$$

Here $y_1 = 0$, $y_2 = 1$m

$$\therefore W = \int_0^1 (20+10y)dy = \left[20y + \frac{10y^2}{2}\right]_0^1$$

$W = 20 + 5$

$W = 25$ J

84. A steam engine delivers 5.4×10^8 J of work per minute and absorbs 3.6×10^9 J of heat per minute from the boiler of the engine. Calculate the efficiency of the engine.

(a) 30% (b) 25%

(c) 20% (d) 15%

AMU-2019

Ans. (d) : Given that,

$Q_1 = 3.6\times10^9$J

$W = Q_1 - Q_2 = 5.4\times10^8$J

We know that,

$$\% \text{ Efficiency } (\eta) = \left(\frac{W}{Q_1}\right) = \left(\frac{Q_1 - Q_2}{Q_1}\right)\times100$$

$$\%\eta = \frac{5.4\times10^8}{3.6\times10^9} \times 100$$

$\%\eta = 15\%$

@apna_pdf

85. A man applying force of 20 N on an object at an angle of 60° from the horizontal. If object moved by 20 m in horizontal direction, then work done by the force on the object is

(a) 300 J (b) 400 J
(c) 100 J (d) 200 J

JIPMER-2019

Ans. (d) : Given, F = 20 N, d = 20m, θ = 60°

We know that,

$$W = \vec{F}.\vec{d}$$
$$= F.d\cos\theta$$
$$= 20\times20\times\cos 60° = 20\times20\times1/2$$
$$= 200\ J$$

86. A lift weighing 500 kg is to be lifted up at a constant velocity of 0.20 m/s. The minimum horse power of the motor to be used is

(a) 1.3 HP (b) 2.3 HP
(c) 1.05 HP (d) 2.05 HP

Assam CEE-2019

Ans. (a) : We know that,

$$\text{Power} = \frac{\text{Work done}}{\text{Time}}$$
$$= \frac{mgh}{t} \quad [\because v = \frac{h}{t} = 0.2\,m/s\,]$$
$$= 500\times10\times0.2 \quad (g = 10\ m/s^2)$$
$$= 1000\ W$$

$$\therefore \text{Horse power of the motor} = \frac{1000}{746} = 1.3\ HP$$

87. A particle of mass 10 g is thrown vertically upwards with a speed of 20ms^{-1}. The work done by the gravitational force during the time the particle moves upward is

(a) 2 J (b) – 2 J
(c) 0.196 J (d) – 0.196 J

TS EAMCET 08.05.2019, Shift-II

Ans. (b) : Given,

$$\text{Mass} = 10g = \frac{10}{1000}kg$$
$$u = 20\ m/s,\ v = 0\ m/s$$

We know that,

Equation of third law of motion,

$$v^2 = u^2 + 2as \quad (\because\ a = -g)$$
$$0 = u^2 - 2gh$$
$$2gh = u^2$$
$$\boxed{h = \frac{u^2}{2g}}$$

The work done by gravity is equal,

$$W_{gravity} = -\,mgh$$
$$= -mg\times\frac{u^2}{2g} = -\frac{mu^2}{2} = -\frac{10\times(20)^2}{2\times1000}$$
$$= -\frac{400\times10}{2\times1000}$$
$$W_{gravity} = -\,2J$$

88. At a certain instant, an object is subjected to a force $\vec{F} = \left[(4.0)\hat{i} - (2.0)\hat{j} + (9.0)\hat{k}\right]N$ while the object's velocity is $\vec{v} = \left[-(2.0)\hat{i} + (4.0)\hat{k}\right]m/s$. The instantaneous rate at which the force does work on the object is

(a) + 28 W (b) + 44 W
(c) – 44 W (d) + 36 W

TS EAMCET 08.05.2019, Shift-I

Ans. (a) : Given,

$$\text{Force } (\vec{F}) = 4.0\hat{i} - 2.0\hat{j} + 9.0\hat{k}$$
$$\text{Velocity } (\vec{v}) = -(2.0)\hat{i} + 0\hat{j} + (4.0)\hat{k}$$

We know that,

$$\text{Power, } P = \vec{F}.\vec{v}$$
$$= (4\hat{i} - 2\hat{j} + 9\hat{k}).(-2\hat{i} + 0\hat{j} + 4\hat{k})$$
$$= 4\times(-2) + (-2)\times0 + 9\times4$$
$$= -8 + 0 + 36$$
$$\boxed{P = 28\,W}$$

89. A force $\vec{F} = 3\hat{i} + 6\hat{j} + 2\hat{k}$ acting on a particle causes displacement $\vec{S} = -4\hat{i} + x\hat{j} + 3\hat{k}$ in the direction of $\vec{F}$. If the work done is 12 J, then value of 'x' is

(a) zero (b) 1
(c) 3 (d) 6

MHT-CET 2019

Ans. (c) : Given that, work done (W) = 12 J

$$\vec{F} = 3\hat{i} + 6\hat{j} + 2\hat{k}$$
$$\vec{S} = -4\hat{i} + x\hat{j} + 3\hat{k}$$
$$\text{Work done} = \vec{F}\cdot\vec{S}$$
$$12 = (3\hat{i} + 6\hat{j} + 2\hat{k})\cdot(-4\hat{i} + x\hat{j} + 3\hat{k})$$
$$12 = -12 + 6x + 6$$
$$x = 3$$

90. Assertion: Work done by or against gravitational force in moving a body from one point to another in independent of the actual path followed between the two points.

Reason: Gravitational forces are conservative forces.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-26.05.2019(M) Shift-1

Ans. (a) : Gravitational force is a conservative force and conservative force, depends only on the initial and final position irrespective of the path taken.

So, work done in moving a body against a conservative force is independent of the path followed.

Hence, both assertion and reasons are true and reason is the correct explanation of assertion.

@apna_pdf

91. A hydraulic automobile lift is designed to lift cars with a maximum mass of 3000 kg. The area of cross- section of the piston carrying the load is 425 cm^2. What maximum pressure would smaller piston have to bear?

(a) 15.82×10^5 Pa (b) 6.92×10^5 Pa
(c) 2.63×10^5 Pa (d) 1.12×10^5 Pa

AIIMS-26.05.2019(M) Shift-1

Ans. (b) : Given, m = 3000 kg, area of cross section (A) = 425 cm^2 = 425 × 10^{-4}m^2, maximum force exerted by the load (F) =3000 × 9.8 N

We know that,

$$P=\frac{F}{A}=\frac{3000\times9.8}{425\times10^{-4}}$$

$$P=6.92\times10^5\,Pa$$

Hence, maximum pressure on the smaller piston can bear is 6.92 × 10^5 Pa.

92. A metal chain of mass 2 kg and length 90 cm over hangs a table with 60 cm on the table. How much work needs to be done to put the hanging part of the chain back on the table? (Let g = 10 m/s^2)

(a) 2 J (b) 10 J
(c) 1 J (d) 3 J

TS-EAMCET-06.05.2019, Shift-1

Ans. (c) : Given, m = 2 kg, l = 90 cm = 0.9 m

Hanging length of chain (l') = (0.9 –0.6) m = 0.3 m

Effective length (The distance of centre of gravity of harging chain length from the table) of the hanging chain is,

$$l_e=\frac{l'}{2}=\frac{0.3}{2}=0.15\,m$$

Mass of the hanging part of chain is,

$$m'=\frac{0.30}{0.90}\times2$$

$$m'=\frac{2}{3}kg$$

work needed to put hanging part of chain back on table

$$\therefore \quad W=m'gl_e$$

$$=\frac{2}{3}\times10\times0.15=1J$$

93. Conservative forces are defined as the force for which,

(a) work done depends only on the initial and final positions.
(b) work done depends on the initial and final positions and also on the path taken.
(c) work done depends only on the path taken.
(d) work done depends only on the initial position.

TS-EAMCET-04.05.2019, Shift-1

Ans. (a): When the work done by a force is independent of the path followed but depends only on the initial and final positions, such a force is known as conservative force.

Example of conservation force are gravitational force, electrostatistics force between two electric charge, spring force in a gravitational force.

94. A force F acting on a body depends on its displacement S as F ∝ $S^{-1/3}$. The power delivered by F will depend on displacement as

(a) $S^{2/3}$ (b) $S^{-5/3}$
(c) $S^{1/2}$ (d) S^0

Manipal UGET-2019

Ans. (d): $F\propto S^{-1/3}$

$$F=kS^{-1/3}$$

$$ma=kS^{-1/3}$$

$$m.v\frac{dv}{dS}=kS^{-1/3}$$

$$mvdv=kS^{-1/3}\,dS$$

By integrating

$$\frac{m.v^2}{2}=k\frac{S^{2/3}}{2/3}$$

$$v^2=\frac{3k}{m}S^{2/3}$$

$$v=\sqrt{\frac{3k}{m}}S^{1/3}$$

Power (P) = F.v

$$=k.S^{-1/3}\sqrt{\frac{3k}{m}}S^{1/3}$$

$$P=k\sqrt{\frac{3k}{m}}S^0$$

So, power depend on S^0.

95. A block of mass 48 kg kept on a smooth horizontal surface is pulled by a rope of length 4m by a horizontal force of 25N applied to the other end. If the linear density of the rope is 0.5 kg m^{-3}, the force acting on the block is

(a) 24 N (b) 25 N
(c) 12 N (d) 13 N

AP EAMCET (21.04.2019) Shift-II

Ans. (a): Given, block of mass (M) = 48 kg

Linear density (λ) = 0.5 kgm^{-3}

Length of rope (l) = 4 m

mass of rope (m) = l × λ (for unit area of cross section)

$$m=4\times0.5=2\text{ kg}$$

So,

Total mass = 48 + 2 = 50 kg

$\therefore$ F = Total mass × a

25 = 50 × a

Acceleration, $a=\frac{1}{2}$ m/s^2

Hence, acting force on block (F') = M × a

$$(F')=48\times\frac{1}{2}$$

$$F'=24\text{ N}$$

96. A man drags a block through 10m on rough surface (μ = 0.5). A force of $\sqrt{3}$ kN acting at 30° to the horizontal. The work done by applied force is

@apna_pdf

(a) Zero (b) 7.5 kJ
(c) 15 kJ (d) 10 kJ

BITSAT-2019

Ans. (c): Given, $d = 10$ m, $\theta = 30^o$, $\mu = 0.5$

$$F = \sqrt{3}\,\text{kN} = \sqrt{3} \times 10^3\,\text{N}$$

Work done by applied force-

$$W = F\,d\cos\theta$$

$$W = \sqrt{3} \times 10^3 \times 10 \times \cos 30^o$$

$$= \sqrt{3} \times 10^3 \times 10 \times \frac{\sqrt{3}}{2}$$

$$= 15 \times 10^3\,\text{J}$$

$$W = 15\,\text{kJ}$$

97. A force of $2\hat{i} + 3\hat{j} + 4\hat{k}$ N acts on a body for 4 second, produces a displacement of $\left(3\hat{i} + 4\hat{j} + 5\hat{k}\right)$ m. The power used is

(a) 9.5 W (b) 7.5 W
(c) 6.5 W (d) 4.5 W

BITSAT-2019

Ans. (a): Given, Force ($\vec{F}$) = $\left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)$ N

Displacement ($\vec{d}$) = $\left(3\hat{i} + 4\hat{j} + 5\hat{k}\right)$ m

Time (t) = 4 sec

We know that,

$$\text{Power} = \left(\frac{W}{t}\right) = \frac{\vec{F}.\vec{d}}{t}$$

$$P = \frac{\left(2\hat{i} + 3\hat{j} + 4\hat{k}\right).\left(3\hat{i} + 4\hat{j} + 5\hat{k}\right)}{4}$$

$$P = \frac{6 + 12 + 20}{4}$$

$$P = \frac{38}{4}$$

$$P = 9.5\text{W}$$

98. A car of mass 'm' accelerates on a level smooth road when a constant power 'P' is delivered to it. If the velocity of the car at any instant is 'v' then its velocity will be doubled after travelling a distance

(a) $\frac{7mv^3}{3P}$ (b) $\frac{4mv^3}{3P}$

(c) $\frac{mv^3}{P}$ (d) $\frac{18mv^3}{7P}$

AP EAMCET-25.04.2018, Shift-I

Ans. (a) : Given, mass of car = m

velocity of car = v m/s

$$P = F.v$$

$$F = \frac{P}{v}$$

$$mv\left(\frac{dv}{ds}\right) = \frac{P}{v}$$

$$ds = \frac{m}{P}v^2 dv$$

Integrating both side, we get–

$$\int_0^s ds = \frac{m}{P}\int_v^{2v} v^2 dv$$

$$s = \frac{7mv^3}{3P}$$

99. The only force acting on a 2 kg body that is moving in xy plane has a magnitude of 5 N. The body initially has a velocity of 4 ms^{-1} in the positive x direction. Sometime later the body has a velocity of 6 ms^{-1} in the positive y direction. The work done on the body by the 5 N force during this time is

(a) 20 J (b) 40 J
(c) 52 J (d) 72 J

AMU-2018

Ans. (a) : Given, m = 2 kg, v_1 = 4m/s , v_2 = 6m/s, F = 5N

According to work-energy theorem,

$$\int F_{net}dx = \Delta KE = (KE)_2 - (KE)_1$$

$$= \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$= \frac{1}{2}\left[2\times(6)^2 - 2\times(4)^2\right]$$

$$= \frac{2}{2}[36-16]$$

$$= 20\text{ J}$$

100. If a machine perform 4000 J output work and 1000 J is inside loss due to friction, then find the efficiency?

(a) 80% (b) 30%
(c) 25% (d) 60%

JIPMER-2018

Ans. (a) : $W_{out} = 4000$J

$W_{loss} = 1000$J

$$W_{total} = W_{out} + W_{loss}$$

$$= 4000\text{ J} + 1000\text{ J}$$

$$= 5000\text{J}$$

$$\therefore\ \eta = \frac{W_{total} - W_{loss}}{W_{total}} \times 100$$

$$\eta = \frac{W_{out}}{W_{total}} \times 100$$

$$\eta = \frac{4000}{5000} \times 100$$

$$\eta = 80\%$$

101. If the efficiency of an engine is 50% and its work output is 500 J, then find input.

(a) 1000 J (b) 500 J
(c) 100 J (d) 250 J

JIPMER-2018

@apna_pdf

Ans. (a) : Given:
Efficiency(η) =50% = 0.50
$W_{output} = 500J$
$W_{input} = ?$
We know that,

$$\text{Efficiency } (\eta) = \frac{W_{output}}{W_{input}}$$

$$W_{input} = \frac{W_{output}}{\eta} = \frac{500}{0.50}$$

$$W_{input} = 1000J$$

102. The efficiency of a heat engine is 1/6. Its when the temperature of sink decreases by 62°C, its efficiency doubles. Then what is the temperature of sources?

(a) 470 K (b) 372 K
(c) 542 K (d) 1042 K

JIPMER-2018

Ans. (b) : $\eta = \frac{1}{6}, \eta' = 2\eta$
Let T_1 = Temperature of sink
T_2 = Temperature of source
Given,

$$T_2' = T_2 - 62$$

We know that,
The efficiency of the Carnot engine can be given as,

$$\eta = 1 - \frac{T_2(K)}{T_1(K)} \quad \text{....(i)}$$

For $\eta = \frac{1}{6}$,

$$\frac{1}{6} = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = \frac{5}{6} \quad \text{....(ii)}$$

For $\eta' = 2\eta$,

$$\eta' = 1 - \frac{T_2'}{T_1}$$

$$2\eta = 1 - \frac{T_2 - 62}{T_1}$$

$$\frac{1}{3} = 1 - \frac{T_2}{T_1} + \frac{62}{T_1}$$

$$\frac{1}{3} = 1 - \frac{5}{6} + \frac{62}{T_1} \quad \text{(from (ii))}$$

$$\frac{62}{T_1} = \frac{1}{3} - \frac{1}{6} = \frac{1}{6}$$

$$T_1 = 6 \times 62$$
$$= 372 \text{ K}$$

103. A Carnot engine absorbs 6×10^5 cal at 227°C. The work done per cycle by the engine, if its sink is maintained at 127°C is

(a) 15×10^8 J (b) 15×10^4 J
(c) 5×10^5J (d) 2×10^4J

JIPMER-2018

Ans. (c) : Given data,
$Q_1 = 6 \times 10^5$ cal
$T_1 = 227°C = 227 + 273 = 500K$
$T_2 = 127°C = 127 + 273 = 400 K$
$Q_2 = ?$ $W = ?$
We know that,
For Carnot engine:–

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

$$Q_2 = Q_1 \frac{T_2}{T_1}$$

$$Q_2 = \frac{400}{500} \times 6 \times 10^5$$

Hence, $Q_2 = 4.8 \times 10^5$ cal

$$W = Q_1 - Q_2$$
$$W = 6 \times 10^5 - 4.8 \times 10^5$$
$$= 1.2 \times 10^5 \text{ cal}$$
$$= 1.2 \times 10^5 \times 4.2$$
$$= 5.04 \times 10^5 \text{ J}$$
$$W \approx 5 \times 10^5 \text{ J}$$

104. When a rubber string is stretched through a distance 'x', the restoring force developed has a magnitude $(px + qx^2 + rx^3)$ where p, q and r are constants. Work done in stretching the unstretched rubber string by a distance '*l*' is

(a) $\frac{pl^2}{2} + \frac{ql^3}{3} + \frac{rl^4}{4}$

(b) $\frac{1}{2}\left[\frac{pl^2}{2} + \frac{ql^3}{3} + \frac{rl^4}{4}\right]$

(c) $pl^2 + ql^3 + rl^4$

(d) $pl + ql + rl^3$

AP EAMCET-25.04.2018, Shift-I

Ans. (a) : Given, $F = px + qx^2 + rx^3$
We know that,
Work done (dW) = F dx

$$\int_0^w dW = \int_0^l (px + qx^2 + rx^3)dx$$

$$W = \left[\frac{px^2}{2} + \frac{qx^3}{3} + \frac{rx^4}{4}\right]_0^l$$

$$W = \frac{pl^2}{2} + \frac{ql^3}{3} + \frac{rl^4}{4}$$

105. A body of mass 2 kg moving in X-Y plane has a potential energy given by U = (6x + 8y) J. The body is at rest at the point (3,2) m. The work to be done by the body to reach another position after 2 s is

(a) 100 J (b) 500 J
(c) 750 J (d) 900 J

AP EAMCET-24.04.2018, Shift-II

Ans. (a) : Given,
Potential energy, U = (6x + 8y) J
Mass (m) = 2 kg.
Time (t) = 2s.
Body is rest at point = (3, 2)

@apna_pdf

$\because U = 6x + 8y.$

Now, $F = \dfrac{-\partial U}{\partial x}\hat{i} + \dfrac{-\partial U}{\partial y}\hat{j}$

$F = -6\hat{i} - 8\hat{j}$

$\therefore a = \dfrac{F}{m} = \dfrac{-6\hat{i} - 8\hat{j}}{2} = -3\hat{i} - 4\hat{j}$

We know that.

$s = ut + \dfrac{1}{2}at^2.$

$\therefore x = x_0 + \dfrac{1}{2}a_x t^2 = 3 + \dfrac{1}{2}(-3)(2)^2 = -3m \qquad [x_o = 3]$

Similarly,

$y = y_0 + \dfrac{1}{2}a_y t^2 = 2 + \dfrac{1}{2}(-4)(2)^2 = -6m \qquad [y_o = 3]$

$\therefore U_0 = 6x_0 + 8y_0 = 6\times 3 + 8\times 2 = 18 + 16 = 34J$

$U_1 = 6x + 8y = 6\times -3 + 8\times -6 = -18 - 48 = -66J$

$\therefore \Delta U = U_0 - U_1 = 34 - (-66) = 100J$

106. Consider a 50 m high water falls, with water flowing at a rate of 1.2×10^6 kg/s. using the power generated due to this process assuming 100% efficiency the number of 60W bulbs that can be light up is

(a) 9.8×10^6 (b) 5.88×10^8
(c) 9.8×10^3 (d) 1000

TS EAMCET 02.05.2018, Shift-II

Ans. (a) : Given data,

Height (h) = 50 m
Mass flow rate (m_r) = 1.2×10^6 kg/s
Power (P) = 60 W

Potential energy (P.E) = $m_r gh$

P.E = $1.2 \times 10^6 \times 9.8 \times 50$
P.E = 588×10^6 J/s

According to question, total potential energy is converted into Electrical energy ($\because$ Efficiency = 100%)

$\therefore$ P.E = E.E = 588×10^6 J/s

Now, number of 60 W bulbs, that can be light up is

$$= \frac{588\times10^6}{60} = 9.8\times10^6.$$

107. A 10 m long iron chain of linear mass density 0.8 kg m^{-1} is hanging freely from a rigid support. If g = 10 ms^{-2}, then the power required to left the chain upto the point of support in 10 second is.

(a) 10 W (b) 20 W
(c) 30 W (d) 40 W

AIIMS-27.05.2018(M)

Ans. (d) : Given,

Length of chain = 10 m
Linear Mass density = 0.8 kg/m

The distance of C.O.M. to the point of vertical support (h) = 5 m

So,

Mass of chain = length × mass density
= 10 × 0.8 = 8 kg

Potential energy of chain = mgh
= 8 × 10 × 5
= 400 J

So,

$$\text{Power (P)} = \frac{\text{Energy}}{\text{Time}} = \frac{400}{10}$$

P = 40 W

108. The work done by a given force on a body depends only on

(a) The force, the displacement and the angle between them
(b) The force, the velocity and the angle between them
(c) The acceleration, the velocity and the angle between them
(d) The force, the velocity and acceleration between them

J&K-CET-2018

Ans. (a) : W = Fs cosθ

Thus, we can say that, the work done by a given force on a body depends on the force, displacement and angle between the force and direction of displacement.

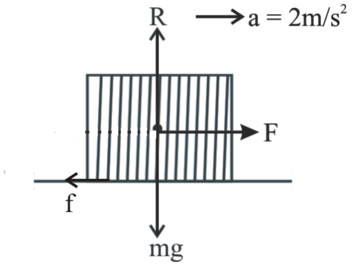
109. A car of mass 1200 kg (together with the driver) is moving with a constant acceleration of 2 m/s^2. How much power does the engine generate at the instance, when the speed reaches 20 m/s? (Assume that the coefficient of friction between the car and the road is 0.5).

(a) 48000 W (b) 120000 W
(c) 168000 W (d) 288000 W

TS-EAMCET-04.05.2018, Shift-2

Ans. (c) : Given, m = 1200 kg, a = $2m/s^2$, μ = 0.5

v = 20m/s, R = mg



Friction force (f) = μ R

$= \mu mg = \dfrac{1}{2}\times1200\times10$

$(\because g=10m/s^2)$

= 6000 N

Force, F = ma = 1200 × 2 = 2400 N

Total Force is,

F = ma + μ mg
F = 2400 + 6000
F = 8400 N

Power (P) = F × v

P = 8400 × 20
P = 168000 W

@apna_pdf

110. An object moves along the circle with normal acceleration proportional to t^{α}, where t is the time and α is a positive constant. The power developed by all the forces acting on the object will have time dependence proportional to

(a) $t^{\alpha-1}$ (b) $t^{\alpha/2}$

(c) $t^{\frac{1+\alpha}{2}}$ (d) $t^{2\alpha}$

TS-EAMCET-04.05.2018, Shift-1

Ans. (a) : Given that, $a_c \propto t^{\alpha}$

Let, circular path of radius = r

Tangential velocity = linear velocity = $v_t = a.t$

Acceleration due to centrifugal force = a_c

So, centrifugal force, $F_c = \dfrac{mv_t^2}{r}$

$$m\times a_c = \frac{mv_t^2}{r}$$

Centrifugal acceleration, $a_c = \dfrac{v_t^2}{r}$ $\quad\because a_c \propto t^{\alpha}$

$$t^{\alpha} = \frac{v_t^2}{r}$$

$$v_t^2 \propto t^{\alpha}$$

$$v_t \propto t^{\alpha/2}$$

or $\quad v_t = k.t^{\alpha/2}$ .....(i)

$\because \quad a = \dfrac{dv_t}{dt}$

$$a = \frac{d}{dt}\left(kt^{\alpha/2}\right) = k.\frac{\alpha}{2}t^{\frac{\alpha}{2}-1} \quad \text{....(ii)}$$

So, power developed is–

$P = F.v_t$

$P = mav_t$ ....(iii)

Putting the value of 'a' and v_t in equation (iii), we get–

$$P = m\frac{k\alpha}{2}t^{\frac{\alpha}{2}-1}.kt^{\frac{\alpha}{2}}$$

$$P = m\frac{k^2\alpha}{2}t^{\frac{\alpha}{2}-1+\frac{\alpha}{2}}$$

$$P = m\frac{k^2\alpha}{2}t^{\alpha-1}$$

$$P \propto t^{\alpha-1}$$

111. A small body of mass 500 g moves on a rough horizontal surface before finally stops. The initial velocity of the body is 2 m/s and coefficient of friction is 0.3. Then, find absolute value of the average power developed by the frictional force during the time of motion. (Take, $g = 10\ m/s^2$)

(a) 1 W (b) 1.5 W

(c) 2 W (d) 2.5 W

TS-EAMCET-07.05.2018, Shift-1

Ans. (b): Given, mass (m) = 500g = 0.5kg

Initial velocity of body (u) = 2 m/s

Coefficient of friction (μ) = 0.3

Frictional force (f) = $\mu mg = 0.3\times 0.5 \times 10 = 1.5$N

$$v_{avg} = \frac{u+v}{2} = \frac{2+0}{2} = 1\text{m/s}$$

Now,

$P_{avg} = f\times v_{avg}$

$P_{avg} = 1.5\times 1$

$P_{avg} = 1.5$ W

112. Consider a drop of rain water having mass 1g falling from a height of 1 km. It hits the ground with a speed of 50 m/s. Take g constant with a value of 10 m/s². The work done by the (i) gravitational force and the (ii) resistive force of air is

(a) (i) −10 J, (ii) −8.25 J

(b) (i) 1.25 J, (ii) −8.25 J

(c) (i) 100 J, (ii) 8.75 J

(d) (i) 10 J, (ii) −8.75 J

NEET- 2017

Ans. (d) : Given data,

Mass (m) = 1 g or 1×10^{-3} kg

Height (h) = 1 km = 1000 m

Velocity (v) = 50 m/s

$g = 10\ m/s^2$

We know that,

Work done by gravitational force (W_g) = mgh

$W_g = 1\times10^{-3}\times 10\times 1000$

$W_g = 10$ J

Change in kinetic energy (ΔK.E) = $\dfrac{1}{2}mv^2 - 0$

$$\Delta K.E = \frac{1}{2}\times1\times10^{-3}\times50\times50-0 = 1.25$$

From Work–Energy theorem ,

$W_g + W_{\text{air resistance}} = \Delta$K.E

$10 + W_{\text{air resistance}} = 1.25$

$W_{\text{air resistance}} = 1.25 - 10$

$= -8.75$ J

113. A body of mass m accelerates uniformly from rest to v_1 in time t_1. The instantaneous power delivered to the body as a function of time

(a) $\dfrac{mv_1^2t}{t_1}$ (b) $\dfrac{mv_1t}{t_1}$

(c) $\dfrac{mv_1t^2}{t_1}$ (d) $\dfrac{mv_1^2t}{t_1^2}$

AMU-2017

Ans. (d) : Given,

mass = m,

Initial velocity (v_i) = 0,

Final velocity (v_f) = v_1

We know that,

Acceleration (a) = $\dfrac{\Delta v}{\Delta t} = \dfrac{v_f - v_i}{\Delta t}$

$$a = \frac{v_1 - 0}{t_1} = \frac{v_1}{t_1}$$

Apply equation of motion-

$v = u + at$

$v = 0 + at$

@apna_pdf

$$v = \frac{v_1}{t_1} \times t$$

Now,

$$\text{Power } (P) = F.v$$

$$P = m.av$$

$$P = m \times \left(\frac{v_1}{t_1}\right) \times \left(\frac{v_1}{t_1}\right) t$$

$$P = \frac{m v_1^2 t}{t_1^2}$$

114. If a particle's position is given by $x = 4 - 12t + 3t^2$ where t is in the seconds and x in meters. What is its velocity at t = 1s? Whether the particle is moving in + x direction or – x direction?

(a) – 6 m/s, + x direction

(b) – 6 m/s, – x direction

(c) 6 m/s, + x direction

(d) 4 m/s, – x direction

AMU-2017

Ans. (b) : Given Relation , $x = 4 - 12t + 3t^2$

Velocity of the particle $(v) = \frac{dx}{dt}$

$$v = \frac{d}{dt}\left(4 - 12t + 3t^2\right)$$

$$v = -12 + 6t$$

At t = 1s, $v = -12 + 6 \times 1$

$v = -$ 6m/s, (– x direction)

115. A balloon has a mass of 10 gram in air. The air escapes from the balloon at a uniform rate with a velocity of 5 cm/s and the balloon shrinks completely in 2.5s. The average force acting on the balloon will be

(a) 200 dyne

(b) 20 dyne

(c) 20 Newton

(d) 2000 dyne

AMU-2017

Ans. (b) : Given data,

Mass of balloon (m) = 10 gram

Velocity (v) = 5 cm/s

Time (t) = 2.5 s

Force (F) = ?

We know that,

$$F = ma$$

$$F = \frac{mv}{t}$$

$$F = \frac{10 \times 5}{2.5}$$

F = 20 dyne

116. The displacement of a body of mass 4 kg varies with time as $s = (t^2+2t)$ m. Now the workdone by all the forces acting on the body during the time interval t=3 s and t=5 s is

(a) 80 J

(b) 320 J

(c) 240 J

(d) 160 J

AP EAMCET-28.04.2017, Shift-II

Ans. (d) : Given that,

Mass (m) = 4 kg

and $s = (t^2 + 2t)$ m

Forces acting on the body during the time

Interval t = 3s to t = 5s

Now,

$$s = t^2 + 2t$$

$$v = \frac{dx}{dt} = 2t + 2$$

From Work– Energy theorem,

$$W_{net} = \Delta K.E$$

$$W_{net} = K_f - K_i = \frac{1}{2} m\left(v_f^2 - v_i^2\right)$$

$$W_{net} = \frac{1}{2} \times 4\left[\left(2 \times 5 + 2\right)^2 - \left(2 \times 3 + 2\right)^2\right]$$

$$W_{net} = \frac{1}{2} \times 4 \times 80$$

$$W_{net} = 160 \text{ J}$$

117. Two 20 g flatworms climb over a very thin wall, 10 cm high. One of the worm is 20 cm long, the other is wider and only 10 cm long. Which of the following statement is correct regarding them?

(a) 20 cm worm has done more work against gravity

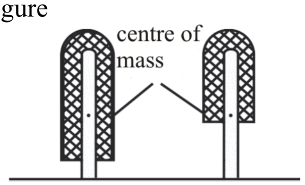
(b) 10 cm worm has done more work against gravity

(c) Both worms have done equal work against gravity

(d) Ratio of work done by both the worms is 4:5

JIPMER-2017

Ans. (b) : The centre of mass is located at the middle of the worm if the worm is folded in half, i.e. at a point one-quarter of the worm's total length from one end, as given in the figure



As per the given condition, the center of mass of the narrow flat worm travels 5 cm up the wall; while that of the board one moves 7.5 cm. Hence, work done by 10 cm worm is more against gravity. Also, the ratio of the work done is 2:3.

118. Consider a particle on which constant forces $\vec{F}_1 = \hat{i} + 2\hat{j} + 3\hat{k}$ N and $\vec{F}_2 = 4\hat{i} - 5\hat{j} - 2\hat{k}$ N act together resulting in a displacement from position $\vec{r}_1 = 20\hat{i} + 15\hat{j}$ cm to $\vec{r}_2 = 7\hat{k}$ cm. The total work done on the particle is

(a) – 0.48 J

(b) + 0.48 J

(c) – 4.5 J

(d) + 4.8 J

TS EAMCET (Engg.)-2017

@apna_pdf

Ans. (a) : $F_1 = \left(\hat{i}+2\hat{j}+3\hat{k}\right)N$

$F_2 = \left(4\hat{i}-5\hat{j}-2\hat{k}\right)N$

$r_1 = 20\hat{i}+15\hat{j}$ cm

$r_2 = 7\hat{k}$ cm

Total force on particle, $F = F_1 + F_2$

$= \left(\hat{i}+2\hat{j}+3\hat{k}\right)+\left(4\hat{i}-5\hat{j}-2\hat{k}\right)$

$= \left(5\hat{i}-3\hat{j}+\hat{k}\right)N$

Displacement of particle, $s = \vec{r}_2-\vec{r}_1$

$= 7\hat{k}-(20\hat{i}+15\hat{j})$

$= \left(-20\hat{i}-15\hat{j}+7\hat{k}\right)$cm

We know that,
Work (W) = F.s

$= \left(5\hat{i}-3\hat{j}+\hat{k}\right).\left(-20\hat{i}-15\hat{j}+7\hat{k}\right)$

$= (-100+45+7)\times10^{-2}$

$= -0.48$ J

119. A motor pump lifts 6 tonnes of water from a well of depth 25 m to the first floor of height 35 m from the ground floor in 20 minutes. The power of the pump (in kW) is: [$g = 10\ ms^{-2}$]

(a) 3 (b) 12
(c) 1.5 (d) 6

Karnataka CET-2017

Ans. (a) : Given,

$g = 10\ m/s^2$

$m = 6$ tonnes $= 6000$ kg

$h_1 = 35m$

$t = 20$ minutes $= 20 \times 60$ s $= 1200$ s.

Depth $(h_2) = 25$ m

Total height $(h) = h_1 + h_2 = (35 + 25) = 60$ m

We know that,

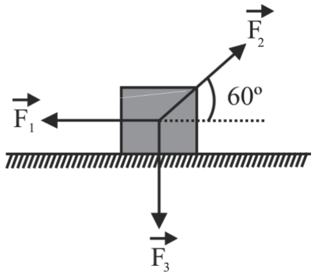
$$\text{Power (P)} = \frac{\text{work}}{\text{time}}$$

$$P = \frac{mgh}{t} \qquad [\because \text{work} = mgh]$$

$$= \frac{6000\times10\times60}{1200} = 3000W$$

$= 3kW$

120. Figure shows three forces applied to a trunk that moves leftward by 3 m over a smooth floor. The force magnitudes are F_1 = 5N, F_2 = 9N and F_3 = 3N. The net work done on the trunk by the three forces.



(a) 1.50 J (b) 2.40 J
(c) 3.00 J (d) 6.00 J

AIIMS-2017

Ans. (a) : Given, $\vec{F}_1 = 5.0N, \vec{F}_2 = 9N, \vec{F}_3 = 3N, \vec{d} = 3m$

We know that, $W = \vec{F}.\vec{d} = Fd\cos\theta$

Work done in $\vec{F}_1$ direction–

$W_1 = F_1\ d\cos\theta_1$

$W_1 = (5)\ (3)\cos0^o = 15J$

$\vec{F}_2$ makes an angle $(\theta_2) = (180^{\circ}-\theta^o) = (180^{\circ}-60^{\circ}) = 120^{\circ}$

Work done in $\vec{F}_2$ direction–

$W_2 = F_2\ d\cos\theta_2$

$W_2 = (9)\times(3)\cos120^o = -13.5J$

Work done in $\vec{F}_3$ direction–

$W_3 = F_3\ d\cos\theta_3$

$W_3 = 3\times3\times\cos90^{\circ} = 0$

Net work done three forces–

$W = W_1 + W_2 + W_3$

$W = 15 - 13.5 + 0$

$W = 1.50J$

121. A force of 20 N acts on a body of mass 2 kg initially at rest. Find the work done in 2 s.

(a) 400 J (b) 20 J
(c) 10 J (d) 5 J

Manipal UGET-2017

Ans. (a): Given,

$F = 20N, m = 2kg, \qquad t = 2sec$

$$\text{Acceleration, } a = \frac{F}{m}$$

$$a = \frac{20}{2} = 10m/s^2$$

From Newton's first law of motion,

$v = u + at$

$v = 0 + 10 \times 2$

$v = 20$ m/s

$$\text{Work done (K.E)} = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\times2\times(20)^2$$

$= 400$ J

122. A car of masses 1500 kg is lifted up a distance of 30 m by crane A in 0.5 minutes. The second crane B does the same job in 1 minute. The ratio of their powers is

(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) 1 : 4
(e) 4 : 1

Kerala CEE - 2016

Ans. (b): Given that,

Mass of car (m) = 1500 kg

Lifting distance (h) = 30 m

Time taken by crane A $(t_1) = 0.5$min $= 30$ sec

Time taken by crane B $(t_2) = 1$min $= 60$ sec

@apna_pdf

As we know that, power (P) = $\frac{mgh}{t}$

$$P \propto \frac{1}{t}$$

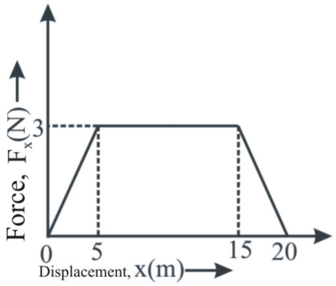
Hence,
$$\frac{P_1}{P_2} = \frac{t_2}{t_1}$$

$$\frac{P_1}{P_2} = \frac{60}{30}$$

$$\frac{P_1}{P_2} = \frac{2}{1}$$

$$\boxed{P_1 : P_2 = 2:1}$$

123. A force F_x acts on a particle such that its position x changes as shown in the figure.

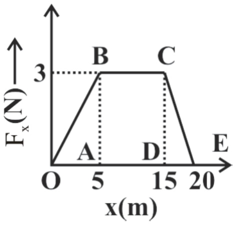


The work done by the particle as it moves from x = 0 to 20 m is

(a) 37.5 J (b) 10 J
(c) 15 J (d) 22.5 J
(e) 45 J

Kerala CEE - 2015

Ans. (e): Work done by a variable force,
W_{net} = Area under the force and displacement curve



W = Area of Δ OBA + Area of ABCD + Area of ΔDCE

$$W = \frac{1}{2}\times 5\times 3 + 10\times 3 + \frac{1}{2}\times 5\times 3$$

$$= \frac{15}{2} + 30 + \frac{15}{2}$$

$$= \frac{15+60+15}{2} = \frac{90}{2}$$

W = 45 J

124. An electric pump is used to fill an overhead tank of capacity 9 m^3 kept at a height of 10 m above the ground. If the pump takes 5 min to fill the tank by consuming 10 kW power, the efficiency of the pump should be (Take g = 10 ms^{-2})

(a) 60% (b) 40%
(c) 20% (d) 30%
(e) 50%

Kerala CEE 2007

Ans. (d): Given,
Volume capacity (V) = 9 m^3, Height (h) = 10 m
Time (t) = 5 minutes, Consuming power = 10 kW
Mass (m) = density × volume = ρ × V
Work done in filling tank

$$W = mgh$$
$$W = (9\times 1000)\times 10\times 10$$
$$W = 9\times 10^5 J$$

Useful power,

$$P = \frac{W}{t}$$

$$P = \frac{9\times 10^5}{5\times 60}$$

$$P = 3kW$$

Hence, efficiency (η) = $\frac{\text{Useful Power}}{\text{Consuming power}}\times 100$

$$= \frac{3}{10}\times 100$$
$$= 30\%$$

125. A rod AB of mass 10 kg and length 4 m rests on a horizontal floor with end A fixed so as to rotate it in vertical plane about perpendicular axis passing through A. If the work done on the rod is 100 J, the height to which the end B be raised vertically above the floor is

(a) 1.5 m (b) 2.0 m
(c) 1.0 m (d) 2.5 m
(e) 3. 0 m

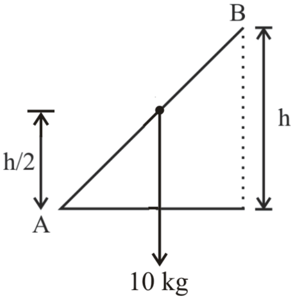
Kerala CEE 2007

Ans. (b): Given, Mass of rod (m) = 10 kg
Length of rod (l) = 4 m
Work (W) = 100 J
Height of end 'B' = h
Height of center of mass (h_G) = $\frac{h}{2}$
Work done (W) = mg h_G

$$W = mg\frac{h}{2}$$

$$100 = 10\times 10\times \frac{h}{2} \quad (\because g = 10 \text{ ms}^{-2})$$

$$h = 2 \text{ m}$$



@apna_pdf

126. When a force is applied on a moving body, its motion is retarded. Then the work done is:

(a) positive
(b) negative
(c) zero
(d) positive and negative
(e) none of the above

Kerala CEE 2004

Ans. (b) : When a force is applied on a moving body is retarded then work done is negative.
As we know that motion is accelerated, work done is positive and when retarded it is negative.
Hence, the work done will be negative.

127. A uniform chain of length L and mass M overhangs a horizontal table with its two-third part on the table. The friction coefficient between the table and the chain is μ. The work done by the friction during the period, the chain slips of the table is.

(a) $-\frac{2}{9}\mu MgL$ (b) $-\frac{6}{7}\mu MgL$
(c) $-\frac{1}{4}\mu MgL$ (d) $-\frac{4}{9}\mu MgL$

UPSEE - 2015

Ans. (a):

Mass of chain = M
Length of chain = L

Length of chain on table = $\frac{2L}{3}$

Mass per unit length = $\frac{M}{L}$

Mass of small element (dm) = $\frac{M}{L}dx$

Friction force on element, $f_x = \mu\, dm\, g$

$$= \mu\frac{M}{L}dx\, g$$

Total work done,

$$dw = f_x \,.\, x$$

$$\int_0^W dw = \int_{\frac{2L}{3}}^{0} f_x \,.\, x$$

$$\int_0^W dw = \frac{\mu Mg}{L}\int_{\frac{2L}{3}}^{0} x\,dx$$

$$W = \frac{\mu Mg}{L}\left[\frac{x^2}{2}\right]_{\frac{2L}{3}}^{0}$$

$$W = -\frac{\mu Mg}{L}\times\frac{\left(\frac{2L}{3}\right)^2}{2}$$

$$W = \ = -\frac{2\mu MgL^2}{9L} = -\frac{2\mu MgL}{9}$$

128. A particle of mass 100 g is thrown vertically upwards with a speed of 5m/s. The work done by the force of gravity during the time the particle goes up is

(a) –1.25 J (b) 1.25 J
(c) 0.5 J (d) –0.5 J

UPSEE - 2010

Ans. (a): Given,
Mass (m) = 100g = 0.1 kg
Speed (v) = 5m/s
Work done to thrown vertically upward,

$$W = -KE = -\frac{1}{2}mv^2$$

$$W = -\frac{1}{2}(0.1)\times5^2 = -\frac{2.5}{2} = -1.25J$$

129. A constant power P is applied to a car starting from rest. If v is the velocity of the car at time t, then

(a) $v \propto t$ (b) $v \propto \frac{1}{t}$
(c) $v \propto \sqrt{t}$ (d) $v \propto \frac{1}{\sqrt{t}}$

UPSEE - 2009

Ans. (c): Power (P) = F.v

$$P = ma\,v$$

$$P = m\frac{dv}{dt}v$$

$$Pdt = mvdv$$

By integration $\int Pdt = \int mvdv$

$$P.t = m\frac{v^2}{2} \qquad (\because P \text{ and } m \text{ are constant})$$

$$v^2 = \frac{2Pt}{m}$$

$$v^2 \propto t$$

$$v \propto \sqrt{t}$$

130. An engineer claims to have made an engine delivering 10 kW power with fuel consumption of 1 g/s. the calorific value of fuel is 2 kcal/g. This claim is:

(a) valid
(b) invalid
(c) depends on engine design
(d) dependent on load

UPSEE - 2006

Ans. (b): For engine,
$P_{out} = 10\text{ kW} = 10 \times 10^3\text{ W}$

$$= \frac{10\times10^3}{4.2} = 2.38\times10^3\text{ cal/s}$$

For fuel,
P_{input} = Fuel consumption × calorific value
= 1 × 2 = 2 Kcal/s
or 2 × 10^3 cal/s
∴ $P_{output} > P_{input}$
Hence, it is never possible. So it is invalid.

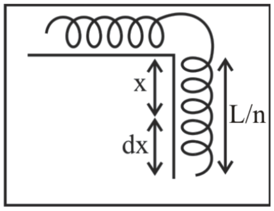
@apna_pdf

131. A chain of mass M is placed on a smooth table with 1/n of its length L hanging over the edge. The work done in pulling the hanging portion of the chain back to the surface of the table is

(a) MgL/n	(b) MgL/2n
(c) MgL/n^2	(d) $MgL/2n^2$

BITSAT-2009

Ans. (d) : Given that,



Total mass of chain = M

Length of chain = L

So, mass per unit length $(\lambda) = \frac{M}{L}$

If we consider a small element dx at a distance 'x' from the table, then the small mass element dm is given as:

$$dm = \frac{M}{L}dx$$

So, work done against gravity in lifting the small mass element dm through x distance is,

$$dw = dm\, gx$$

So, $$\int_0^W dw = \int_0^{L/n}\left(\frac{Mg}{L}\right)xdx = \frac{Mg}{L}\int_0^{L/n} xdx$$

$$W = \frac{Mg}{L}\left[\frac{x^2}{2}\right]_0^{L/n} = \frac{Mg}{2L}\left[x^2\right]_0^{L/n}$$

$$W = \frac{Mg}{2L}\left(\frac{L}{n}\right)^2 = \frac{Mg}{2L}\times\frac{L^2}{n^2}$$

$$W = \frac{MgL}{2n^2}$$

132. If the unit of force and length be each increased by four times, then the unit of energy is increased by

(a) 16 times	(b) 8 times
(c) 2 times	(d) 4 times

BITSAT-2012

Ans. (a): Energy = Work = Force × Displacement

$W_1 = F \times d$

If F & d increased by 4 times each

$W_2 = 4F \times 4d = 16Fd = 16W_1$

Hence unit of energy will increase by 16 times.

133. Which of the following must be known in order to determine the power output of an automobile?

(a) Final velocity and height
(b) Mass and amount of work performed
(c) Force exerted and distance of motion
(d) Work performed and elapsed time of work

BITSAT-2012, 2016

Ans. (d): Power is equal to energy or work per unit time.

Power, $P = \frac{dW}{dt}$

So, power can be defined as the rate of doing work, also for automobile.

134. A force $F=Ay^2 + By + C$ acts on a body in the y-direction. Find the work done by this force during a displacement y= –a to y= + a.

(a) $\frac{2Aa^3}{3}$	(b) $\frac{2Aa^3}{3}+2Ca$
(c) $\frac{2Aa^3}{3}+\frac{Ba^3}{2}+Ca$	(d) None of these

CG PET- 2014

Ans. (b): Force (F) = $Ay^2 + By + C$ (in y direction)

Work done by this force (y = –a to y = + a)

$$W = \int_{-a}^{+a} F.dy$$

$$W = \int_{-a}^{+a}\left(Ay^2 + By + C\right)dy$$

$$W = \left[\frac{Ay^3}{3}\right]_{-a}^{a} + \left[\frac{By^2}{2}\right]_{-a}^{a} + \left[Cy\right]_{-a}^{a}$$

$$W = \frac{A\left(a^3+a^3\right)}{3} + B\left(\frac{a^2-a^2}{2}\right) + C\left(a+a\right)$$

$$W = \frac{2}{3}Aa^3 + 0 + 2aC$$

$$W = \frac{2}{3}Aa^3 + 2Ca$$

135. A particle of mass m is tied to one end of a string of length *l* and rotated through the other end along a horizontal circular path with speed v. The work done in half horizontal circle is

(a) zero	(b) $\left(\frac{mv^2}{l}\right)2\pi l$
(c) $\left(\frac{mv^2}{l}\right)\pi l$	(d) $\left(\frac{mv^2}{l}\right)l$

CG PET- 2008

Ans. (a): In horizontal circular path angle of particle is $(\theta = 90^o)$.

We know that,

$W = F.d\cos\theta$

$W = F.d\cos 90^o$

$W = F.d \times 0$

$W = 0$

Hence, work done by centripetal force in uniform circular motion is always equal to zero.

@apna_pdf

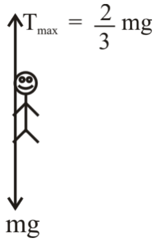
136. With what minimum acceleration can a fireman slide down a rope while breaking strength of the rope is $\frac{2}{3}$ of the weight?

(a) $\frac{2}{3}g$ (b) g

(c) $\frac{1}{3}g$ (d) Zero

Manipal UGET-2010

Ans. (c):



Breaking strength of rope, $T = \frac{2}{3}(mg)$

According to Newton's law of motion–

$$mg - T = ma$$

$$mg - \frac{2}{3}mg = ma$$

$$\frac{mg}{3} = ma$$

$$a = \frac{g}{3}$$

137. Three concurrent co-planar forces 1 N, 2 N and 3N acting along different directions on a body

(a) can keep the body in equilibrium if 2 N and 3 N act at an acute angle

(b) can keep the body in equilibrium if 1 N and 2 N act at right angle

(c) cannot keep the body in equilibrium

(d) can keep the body in equilibrium in 1 N and 3 N act at an acute angle

Manipal UGET-2009

Ans. (c): In 1 N and 2 N force act in one direction and 3N force act is opposite direction and balance them. Three forces are pointing in separate direction, indicating that they are not in equilibrium.

138. A ball falls from 20 m height on floor and rebounds to 5 m. Time of contact is 0.02 s. Find acceleration during impact.

(a) 1200 m/s^2 (b) 1000 m/s^2

(c) 2000 m/s^2 (d) 1500 m/s^2

Manipal UGET-2010

Ans. (d) : From Newton second law of motion force acting on a body is equal to the rate of change of momentum.

Force, $F = \frac{\Delta p}{\Delta t}$

$$ma = \frac{mv_2 - (-mv_1)}{\Delta t}$$

$$a = \frac{v_2 + v_1}{\Delta t} \quad ....(i)$$

From Newton's third law of motion–

$$v_2^2 = u^2 + 2gh$$

$$v_2^2 = 0 + 2 \times 10 \times 20$$

$$v_2 = \sqrt{400}$$

$$v_2 = 20\,m/s \quad \text{and} \quad v_1 = 10\,m/s$$

similarly,

$$v_1^2 = 2gh_1 = 2 \times 10 \times 5$$

$$v_1 = 10\ m/sec$$

Putting the value of v_1 and v_2 in equation (i)-

$$a = \frac{20+10}{0.02} = 1500\ m/s^2$$

139. To maintain a rotar at uniform angular speed of 200 rad/s, an engine needs to transmit a torque of 180 Nm. What is the power required by engine? (Assume efficiency of engine to be 80%)

(a) 36 kW (b) 18 kW

(c) 45 kW (d) 54 kW

JCECE-2011

Ans. (a) : Given,

Required torque (T) = 180 N-m

Angular speed (ω) = 200 rad/s

The power (P) required by the engine is given by,

$$P = T.\,\omega$$

$$= 180 \times 200 = 36000\ W = 36\ kW$$

140. A force of $(7\hat{i}+6\hat{k})$ makes a body to move on a plane with the velocity $(3\hat{j}+4\hat{k})$. The power developed is :

(a) $\sqrt{45}$ (b) 45

(c) 24 (d) $\sqrt{24}$

JCECE-2004

Ans. (c) : Given, force $(\vec{F}) = (7\hat{i}+6\hat{k})N$, velocity $(\vec{v}) = (3\hat{j}+4\hat{k})m/s$

We know that,

Power (P) = $\vec{F}.\vec{v}$

$$= (7\hat{i}+6\hat{k}).(3\hat{j}+4\hat{k})$$

$$= (21\hat{i}.\hat{j}+28\hat{i}.\hat{k}+18\hat{k}.\hat{j}+24\hat{k}.\hat{k})$$

$$= 21 \times 0 + 28 \times 0 + 18 \times 0 + 24 \times 1$$

$$P = 24\ W$$

141. If 120 J of work is done in 2 minutes by a water pump, the power of the pump is

(a) 14.4 kW (b) 240 W

(c) 60 W (d) 1 W

COMEDK-2012

@apna_pdf

Ans. (d) : Given, W = 120 J, t = 2 min = 120 sec

$$\text{Power} = \frac{W}{t} = \frac{120}{120} = 1\,\text{Watt}$$

142. One coolie takes 1 minute to raise a suitcase through a height of 2 m but the second coolie takes 30 s to raise the same suitcase to the same height. The powers of two coolies are in the ratio

(a) 1:3 (b) 2:1

(c) 3:1 (d) 1:2

NEET-2013

COMEDK-2013

Ans. (d) : Given, t_1 = 1min. = 60 s, h = 2 m, t_2 = 30 s

We know that, $P = \frac{W}{t} = \frac{F\times h}{t}$

For first coolie, power is given by,

$$P_1 = \frac{F\times h}{t_1} = \frac{F\times 2}{60} \quad \text{.... (i)}$$

For second coolie, power is given by,

$$P_2 = \frac{F\times h}{t_2} = \frac{F\times 2}{30} \quad \text{.... (ii)}$$

On dividing equation (i) & (ii), we get-

$$\frac{P_1}{P_2} = \frac{F\times 2\times 30}{60\times F\times 2}$$

$$\frac{P_1}{P_2} = \frac{1}{2} \text{ or } 1:2$$

143. A pump on the ground floor of a building can pump up water to fill the tank of 30 m^3 in 15 min. If the tank is 40 m above the ground and the efficiency of the pump is 30%, the power consumed by the pump is (g = 10 m s^{-2})

(a) 4.4 kW (b) 44 kW

(c) 440 kW (d) 0.44 kW

COMEDK-2014

Ans. (b) : Given, volume of the tank(v) = 30 m^3, time (t) = 15 min = 15×60 = 900 sec, height(h) = 40 m, efficiency (η) = 30 %, density of water (ρ) = 10^3 kg/m^3

∵ Power required to lift the water

$$P_r = \frac{W}{t} = \frac{mgh}{t} = \frac{\rho vgh}{t}$$

$$P_r = \frac{10^3\times 30\times 10\times 40}{900} = 13333.3\,\text{Watt}$$

Let, P be the power consumed only 30 % (efficiency)

So, $$\frac{30}{100}P = P_r$$

$$P = \frac{100}{30}\times P_r$$

$$P = \frac{100}{30}\times 13333.33$$

P = 44.4 kW

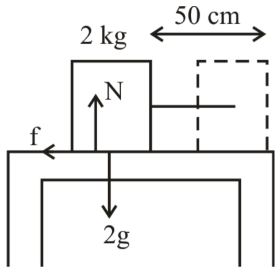
144. A 2 kg mass lying on a table is displaced in the horizontal direction through 50 cm. The work done by the normal reaction will be

(a) 10 J (b) 0

(c) 100 erg (d) 100 J

COMEDK-2015

Ans. (b) :



Normal reaction on the mass by the table is perpendicular to the horizontal displacement. Hence work done by normal will be zero.

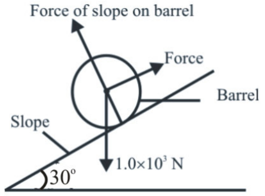
$$\text{Work done} \quad (W) = \vec{F}.\vec{S}$$

$$W = FS\cos\theta$$

$$W = FS\cos 90°$$

$$W = 0$$

145. The diagram shows a barrel of weight 1.0×10^3 N on a frictionless slope inclined at 30° to the horizontal. The force is parallel to the slope. What is the work done in moving the barrel a distance of 5.0 m up the slope?

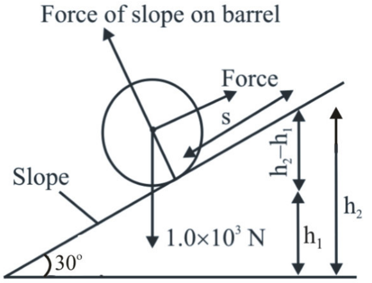


(a) 2.5×10^3 J (b) 4.3×10^3 J

(c) 5.0×10^3 J (d) 1.0×10^3 J

COMEDK-2015

Ans. (a): Given, weight of barrel (mg) = 1.0 × 10^3 N



Work done in moving the barrel on the frictionless slope = change in potential energy of barrel.

$$W = mg(h_2 - h_1)$$

$$(h_2 - h_1) = s\sin 30^\circ = 5\sin 30^\circ = 2.5\,\text{m}$$

$$\therefore \quad W = 1.0\times 10^3\times 2.5 = 2.5\times 10^3\,\text{J}$$

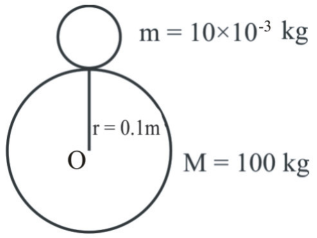
@apna_pdf

146. A particle of mass 10 gm is kept on the surface of uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them to take the particle far away from the sphere (you may take $G = 6.67 \times 10^{-11}$ Nm²/kg²)

(a) 3.33×10^{-10} J (b) 13.34×10^{-10} J
(c) 6.67×10^{-10} J (d) 6.67×10^{-9} J

AIIMS-2008

Ans. (c) : Given, mass of particle (m)=10g $=10\times10^{-3}$ kg, mass of uniform sphere (M) = 100 kg, radius (r) = 10cm = 0.1 m



Work can be only be done when it is against some force. So work done can be written as

$$\because \quad W = U_f - U_i$$

$$W = 0 - \left(-\frac{GMm}{r}\right)$$

$$W = \frac{6.67\times10^{-11}\times100\times10\times10^{-3}}{0.1}$$

$$W = 6.67\times10^{-10}\,\text{J}$$

147. A block of mass 10 kg is moving in x-direction with a constant speed of 10 m/sec. It is subjected to a retarding force F = – 0.1x Joule/metre during its travel from x = 20 metre to x = 30 metre. Its final kinetic energy will be:

(a) 475 joule (b) 450 joule
(c) 275 joule (d) 250 joule

AIIMS-2010, 2005

Ans. (a) : Given, F = – 0.1x J/m, x_1 = 20 m, x_2 = 30m, v = 10 m/sec, m = 10 kg

We know that, $\text{K.E.} = \frac{1}{2}mv^2$

Then, initial kinetic energy

$$(\text{K.E.})_i = \frac{1}{2}\times10\times(10)^2$$

$$(\text{K.E.})_i = 500\ \text{J}$$

The work done from x_1 = 20 m to x_2 = 30 m

$$\int dw = \int_{x1}^{x_2} F.dx$$

$$\int d\,w = -\int_{20m}^{30m} 0.1x\,dx$$

$$W = -0.1\left[\frac{x^2}{2}\right]_{20}^{30}$$

$$W = -0.05\left[30^2 - 20^2\right]$$

$$W = -0.05[900 - 400]$$

$$W = -25\text{J}$$

Therefore, final K.E. is equal to

$$W = (\text{K.E.})_f - (\text{K.E.})_i$$

$$(\text{K.E.})_f = (\text{K.E.})_i + W$$

$$= 500 - 25$$

$$(\text{K.E.})_f = 475\ \text{J}$$

148. A force $(3\hat{i}+4\hat{j})$ Newton acts on a body and displaced it by $(3\hat{i}+4\hat{j})$ meter. The work done by the force is

(a) 5 J (b) 25 J
(c) 10 J (d) 30 J

AIIMS-2001

Ans. (b) : Given, Force, $\vec{F}=(3\hat{i}+4\hat{j})$, Displacement, $\vec{s}=(3\hat{i}+4\hat{j})$

We know that, $W = \vec{F}.\vec{s}$

$$W = (3\hat{i}+4\hat{j})(3\hat{i}+4\hat{j})$$

$$W = 9\hat{i}.\hat{i}+12\hat{i}.\hat{j}+12\hat{j}.\hat{i}+16\hat{j}.\hat{j} \qquad (\because \hat{j}\times\hat{i} = 0)$$

$$W = 9 + 16 = 25\ \text{J}$$

149. If under the action of a force $(4\hat{i}+\hat{j}+3\hat{k})$ N, a particle moves from position $r_1 = 3\hat{i}+2\hat{j}-6\hat{k}$ to positions $r_2 = 14\hat{i}+13\hat{j}+9\hat{k}$ then the work done will be–

(a) 50 J (b) 75 J
(c) 100 J (d) 175 J

JIPMR-2004
BCECE-2012

Ans. (c) : Given,

$F = (4\hat{i}+\hat{j}+3\hat{k})$, $r_1 = 3\hat{i}+2\hat{j}-6\hat{k}$ and $r_2 = 14\hat{i}+13\hat{j}+9\hat{k}$

Displacement $(r_2 - r_1)$

$$= (14\hat{i}+13\hat{j}+9\hat{k})-(3\hat{i}+2\hat{j}-6\hat{k})$$

$$r_2 - r_1 = 11\hat{i}+11\hat{j}+15\hat{k}$$

Work done

W = F. s

$$= (4\hat{i}+\hat{j}+3\hat{k}).(11\hat{i}+11\hat{j}+15\hat{k}) \quad [\therefore\ \hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1]$$

W = 44 + 11 + 45 = 100 J

150. A constant power P is applied to a particle of mass m. The distance travelled by the particle when its velocity increases from v_1 to v_2 is (neglect friction)

(a) $\frac{m}{3P}(v_2^3 - v_1^3)$ (b) $\frac{m}{3P}(v_2 - v_1)$
(c) $\frac{3P}{m}(v_2^2 - v_1^2)$ (d) $\frac{m}{3P}(v_2^2 - v_1{}^2)$

BCECE-2011

Ans. (a) : We know,

Power (P) = F.v = ma.v

$$\text{Acceleration } a = \frac{P}{mv}$$

@apna_pdf

$$\frac{v.dv}{ds}=\frac{P}{mv}$$

$$v^2dv=\frac{P}{m}ds$$

Integrating on both side

$$\frac{P}{m}\int_{o}^{s}ds=\int_{v_1}^{v_2}v^2dv$$

$$\frac{Ps}{m}=\frac{1}{3}\left(v_2^3-v_1^3\right)$$

Then, $s=\frac{m}{3P}\left(v_2^3-v_1^3\right)$

151. A body moves a distance of 10m along a straight line under a action of 5N force. If work done is 25J, then angle between the force and direction of motion of the body will be–

(a) 75° (b) 60°
(c) 45° (d) 30°

BCECE-2007

Ans. (b) : Given :-
Distance (s) = 10 m
Force (F) = 5 N
Work done (W) = 25 J
Angle between the force and direction, θ = ?
Work done W = F.s cos θ

$$25 = 5 \times 10\cos\theta$$

$$25 = 50\cos\theta$$

$$\cos\theta=\frac{25}{50}$$

$$\cos\theta=\frac{1}{2}$$

$$\theta = 60^0$$

152. A wire is stretched by 1mm by a force of 1kN. The work done in stretching the wire is :

(a) 5 erg (b) 5 J
(c) 0.5 erg (d) 0.5 J

BCECE-2005

Ans. (d) : Given that,
$F = 1\text{ kN} = 1000\text{ N}$
$x = 1\text{mm} = 1\times10^{-3}\text{ m}$
The work done in stretching the wire

$$W=\frac{1}{2}F.x$$

$$W=\frac{1}{2}\times1000\times1\times10^{-3}$$

$$W=\frac{1}{2}$$

$$W = 0.5\text{ J}$$

153. A body is acted upon by a force proportional to square of distance covered. If the distance covered is denoted by x, then work done by the force will be proportional to

(a) x (b) x^2
(c) x^3 (d) x^{-2}

SCRA-2013

Ans. (c) : Force, $F\propto x^2$

$$F = kx^2$$

Work done, $W=\int F.dx=\int kx^2dx$

$$W=k\int x^2dx$$

$$W=k\frac{x^3}{3}$$

So,

$$W\propto x^3$$

154. A body is acted upon a force which varies inversely as the distance x covered, the work done on the body is proportional to:

(a) x^2 (b) x
(c) $\sqrt{X}$ (d) $\log_e x$

SCRA-2011

Ans. (d) : $F\propto\frac{1}{x}$ (where x = distance)

$$F=\frac{k}{x}$$

$$W=\int\vec{F}.d\vec{x}=\int\frac{k}{x}dx$$

$$W=k\int\frac{1}{x}dx$$

$$W = K\log_e x + c$$

So, $W\propto\log_e x$

155. A car is driven by a constant power P. If the car moves over a distance x, then velocity attained by the car will be proportional to

(a) $x^{\frac{1}{3}}$ (b) $x^{\frac{1}{2}}$
(c) $x^{-\frac{1}{2}}$ (d) $x^{-\frac{1}{3}}$

SCRA-2010

Ans. (a) : Power, P = F.v ...(i)
We know that,

Force, $F=ma=m\frac{dv}{dt}=m\frac{dv}{ds}\frac{ds}{dt}=mv\frac{dv}{ds}$

So, from equation (i)-

$$P = F.v\ =mv\frac{dv}{ds}v$$

$$P=mv^2\frac{dv}{ds}$$

$$P.ds = mv^2dv$$

$$\therefore\quad P\int_0^x ds=m\int_0^v v^2dv$$

$$P[x-0]=m\left[\frac{v^3}{3}\right]_0^v$$

$$Px=\frac{mv^3}{3}$$

$$v^3=\frac{3Px}{m},\qquad v=\left[\frac{3Px}{m}\right]^{1/3}$$

$$v\propto x^{1/3}$$

@apna_pdf

156. A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in the t is proportional to

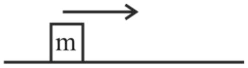
(a) $t^{1/2}$ (b) $t^{3/4}$

(c) $t^{3/2}$ (d) t^2

SCRA-2009, 2010

Ans. (c) : Given, power (P) is the constant.

Distance moved



$$\text{Power}=\frac{E}{t}=\frac{\frac{1}{2}mv^2}{t}=C$$

$$\frac{v^2}{t}=C$$

$$v^2=Ct$$

$$v=\sqrt{Ct}$$

$$v=\sqrt{C}t^{\frac{1}{2}}$$

$$\frac{dx}{dt}=\sqrt{C}t^{\frac{1}{2}}$$

$$\int dx=\sqrt{C}\int t^{\frac{1}{2}}dt$$

$$x=\sqrt{C}\frac{t^{\frac{3}{2}}}{\frac{3}{2}}+C_1$$

$$x=\frac{2\sqrt{C}}{3}t^{\frac{3}{2}}+C_1$$

$$x\propto t^{\frac{3}{2}}$$

157. A body of mass m is travelling with a velocity u. When a constant retarding force F is applied, it comes to rest after travelling a distance s_1. If the initial velocity is 2u, with the same force F, the distance travelled before it comes to rest is s_2. Then,

(a) $s_2=4s_1$ (b) $s_2=2s_1$

(c) $s_2=\frac{s_1}{2}$ (d) $s_2=s_1$

Karnataka CET-2012

Ans. (a) : By work energy theorem,

$$F.s_1=\frac{1}{2}mu^2 \qquad ....(i)$$

$$F.s_2=\frac{1}{2}m(2u)^2 \qquad ....(ii)$$

on dividing equation (ii) by (i), we get -

$$\frac{F.s_2}{F.s_1}=\frac{\frac{1}{2}m4u^2}{\frac{1}{2}mu^2}$$

$$s_2=4s_1$$

158. S. I. unit of power is

(a) joule (b) erg

(c) newton (d) watt

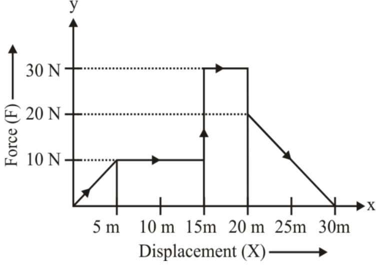
J&K CET- 2011

Ans. (d) : We know,

$$\text{Power }(P)=\frac{\text{Work}}{\text{Time}}$$

The S.I. unit of power is $\frac{\text{Joule}}{\text{Second}}=\text{watt}$

159. Given below is a graph between a variable force (F) (along y–axis) and the displacement (X) (along x–axis) of a particle in one dimension. The work done by the force in the displacement interval between 0 m and 30 m is

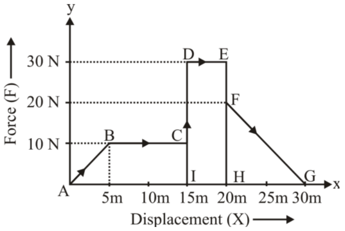


(a) 275 J (b) 375 J

(c) 400 J (d) 300 J

J&K CET- 2010

Ans. (b) :



Work done = Area under the force × displacement graph

= Area of trapezium ABCI + Area of rectangle IDEH +Area of triangle FHG

$$=\left[\frac{1}{2}(10+15)10\right]+[5\times30]+\left[\frac{1}{2}\times10\times20\right]$$

$$=125+150+100=375\text{ J}$$

160. A man does a given amount of work in 10 sec. Another man does the same amount of work in 20 sec. The ratio of the output power of first man to the second man is

(a) 1 (b) 1/2

(c) 2/1 (d) none of these

J&K CET- 2005

Ans. (c) : Let W is the amount of work which is done by the men

We know,

$$\text{Power}=\frac{\text{Work done}}{\text{Time}}$$

$$\frac{P_1}{P_2}=\frac{W/10}{W/20}=\frac{20}{10}$$

$$\frac{P_1}{P_2}=\frac{2}{1}$$

@apna_pdf

161. If the heart pusher 1 cc of blood in one second under pressure 20000 N m^{-2}, the power of heart is

(a) 0.02 W
(b) 400 W
(c) 5×10^{-10} W
(d) 0.2 W

J&K CET- 2005

Ans. (a) : Given that-

Pressure (P) = 20000 N/m^2

Change in volume = 1cc = 10^{-6} m^3

Power = pressure × volume per second

$= 20000 \times 1 \times 10^{-6} = 0.02$ W

162. A particle moves along the x-axis from $x = x_1$ to $x = x_2$ under the action of a force given by F =2x. Then the work done in the process is

(a) zero
(b) $x_2^2 - x_1^2$
(c) $2x_2(x_2 - x_1)$
(d) $2x_1(x_1 - x_2)$

J&K CET- 2003

Ans. (b) : Given that, F = 2x

Work done = ∫ F.dx

$$= \int_{x_1}^{x_2} 2x dx = 2\left[\frac{x^2}{2}\right]_{x_1}^{x_2} = \left(x_2^2 - x_1^2\right)$$

163. A body moves a distance of 10 m along a straight line under action of a force of 5N. If work done is 25 J, the angle which force makes with direction of motion of body is

(a) 60°
(b) 90°
(c) 0°
(d) 30°

J&K CET- 1999

Ans. (a) : Given that -

Distance (s) = 10m

Force (F) = 5N

Work done (W) = 25 J

Now,

The work done by a force-

W = Fs cosθ

$$\cos\theta = \frac{W}{Fs} = \frac{25}{5 \times 10} = \frac{1}{2}$$

$$\theta = \cos^{-1}\left(\frac{1}{2}\right) = 60°$$

So, the force acting on the body makes an angle of 60° with the direction of motion of the body.

164. The power (P) of an engine lifting a mass of 100 kg upto a height of 10 m in 1 min is

(a) P = 163.3 W
(b) P = 9800 W
(c) P = 10000 W
(d) P = 5000 W

J&K-CET-2014, 2013

Ans. (a) : Given,

m = 100 kg, h = 10 m and t = 1 min = 60 sec

Work done by engine = Change in P.E. of mass

W = mgh

W = 100×9.8×10 J

$$\text{Power} = \frac{\text{work done}}{\text{time}}$$

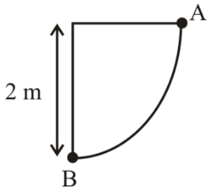
$$= \frac{100 \times 9.8 \times 10}{60} = 163.3 \text{ watt}$$

165. A block of mass 3 kg starts from rest and slides down a curved path in the shape of a quarter-circle of radius 2 m and reaches the bottom of path with a 4 m/s speed. If g is 10 m/s^2, the amount of work done against friction is

(a) 60 J
(b) 36 J
(c) 24 J
(d) 12 J

J&K-CET-2015

Ans. (b) : Given, m = 3kg, v = 4 m/s and g = 10 m/s^2



According to the law of conservation of energy,

P.E. = K.E. + work done by friction (W_s)

$$mgh = \frac{1}{2}mv^2 + W_s$$

$$W_s = mgh - \frac{1}{2}mv^2$$

$$= 3 \times 10 \times 2 - \frac{1}{2} \times 3 \times 4^2$$

$= 60 - 24 = 36$ J

166. Identify the false statement from the following

(a) work-energy theorem is not independent of Newton's second law
(b) Work-energy theorem holds in all inertial frames
(c) Work done by friction over a closed path is zero
(d) No potential energy can be associated with friction
(e) Work done is a scalar quantity

KERALA CEE - 2010

Ans. (c) : Friction is non-conservative because the amount of work done by friction depends on the path and work done by non-conservative force over a closed path is non-zero.

167. A body is moved from rest in a straight line by means of a machine supplying constant power. The distance S moved by the body in time t is proportional to

(a) $t^{1/4}$
(b) $t^{3/4}$
(c) $t^{3/2}$
(d) t^2

CG PET- 2011

Ans. (c) : We know that,

Power (P) = F. v ....(i)

$$\text{Velocity (v)} = \frac{S}{t}$$

Force (F) = ma

$$\text{Acceleration } a = \frac{S}{t^2}$$

$$\therefore \quad F = \frac{mS}{t^2} \qquad ....(ii)$$

@apna_pdf

From equation (i) and (ii), we get-

$$P = \frac{mS}{t^2} \times \frac{S}{t} \qquad \left(\because v = \frac{S}{t}\right)$$

$$P = \frac{mS^2}{t^3}$$

$$S^2 = \frac{P\,t^3}{m}$$

$$S = \sqrt{\frac{P}{m}}\left(t^{3/2}\right)$$

$$S \propto t^{3/2}$$

Since, the power and mass of the body is constant, so the distance covered by the body is proportional to the 3/2th power of time.

168. A motor of power P_0 is used to deliver water at a certain rate through a given horizontal pipe. To increase the rate of flow of water through the same pipe n times, the power of the motor is increased to P_1. The ratio of P_1 to P_0 is

(a) n:1 (b) n^2:1

(c) n^3:1 (d) n^4:1

VITEEE-2009

Ans. (c) : Given,

P_0 = power of motor at flow velocity v_0

P_1 = power of motor at flow velocity (v_1)

Let's $\dot{m}$ = mass flow rate

$\dot{m} = \rho Av$ (A = pipe area, v= flow velocity)

$$\text{Power} = \frac{\dot{m}v^2}{2} = \frac{\rho Av \times v^2}{2}$$

$$\text{Power} = \frac{\rho Av^3}{2}$$

Then,

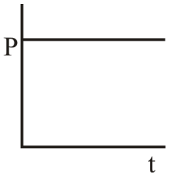
$$P_0 = \frac{\rho Av_0^3}{2}$$

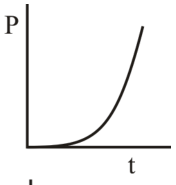
$$P_1 = \frac{\rho Av_1^3}{2} = \frac{\rho A(nv_0)^3}{2} \qquad (\because v_1 = nv_0)$$

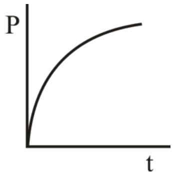
$$\frac{P_1}{P_0} = \frac{(nv_0)^3}{v_0^3} = \frac{n^3}{1}$$

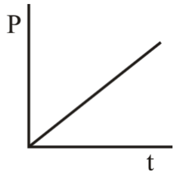
$P_1 : P_0 = n^3 : 1$

169. A motor drives a body along a straight line with a constant force. The power P developed by the motor must vary with time t according to

(a)


(b)


(c)


(d)


AIIMS-2012

Ans. (d) : Given,

Force (F) = constant

Power = P

If force is constant then acceleration will also constant

Thus,

v = at

$\because$ P = F.v

P = F × at

Where power varies linearly with time since both F and a are constant.

$\therefore P \propto t$

Here, power is directly proportional to time, so, the graph between power and time will be a straight line and passing through the origin.

170. An 80 kg person is parachuting and is experiencing a downward acceleration of 2.8 m/s^2. The mass of the parachute is 5 kg. The upward force on the open parachute is (Take $g = 9.8\ m/s^2$)

(a) 595 N (b) 675 N

(c) 456 N (d) 925 N

AIIMS-2009

Ans. (a) : Given,

Mass of person (m_1) = 80 kg

Mass of parachute (m_2) = 5 kg

Downward acceleration (a) = 2.8 m/s^2

Total mass (M) = $m_1 + m_2$

= 80 + 5 = 85 kg

Since, parachute will experience downward force

So,

F = Mg – Ma

F = 85 × 9.8 – 85 × 2.8

= 85 (9.8 – 2.8) = 85 × (7)

F = 595 N

So, upward force on the open parachuting is 595 N

171. A body of mass 6 kg is acted upon by a force which causes a displacement in it given by $x = \frac{t^2}{4}$ meter where 't' is the time in second. The work done by the force in 2 seconds is

(a) 12 J (b) 9 J

(c) 6 J (d) 3 J

WB JEE 2011

Ans. (d) : Given that,

The displacement of a body is $x = \frac{t^2}{4}$

$$\therefore \text{Velocity } (v) = \frac{dx}{dt} = \frac{1}{4} \times 2t = \frac{t}{2}$$

Initial velocity (u) = $[v]_{t=0} = 0$

Final velocity (v) = $[v]_{t=2} = \frac{2}{2} = 1\,m/s$

From work-energy theorem, W = ΔK.E.

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\Rightarrow \quad W = \frac{1}{2} \times 6 \times 1^2 - 0$$

$$\Rightarrow \quad W = 3\ J$$

@apna_pdf

172. A cubical vessel of height 1 m is full of water. What is the amount of work done in pumping water out of the vessel?
(Take g = 10 ms^{-2})

(a) 1250 J (b) 5000 J
(c) 1000 J (d) 2500 J

WB JEE 2011

Ans. (b) : The height of cubical vessel, h = 1m
The center of mass of the water in the cubical vessel lies at CM, i.e. $h' = \frac{h}{2} = \frac{1}{2}m$

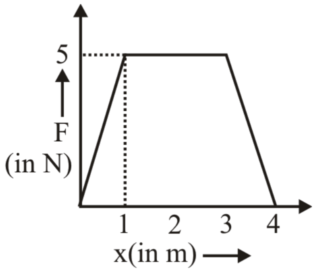
Volume of the water (V) = $h^3 = 1^3 = 1m^3$

$\therefore$ Mass of water (m) = ρV = 1000 × 1 =1000 kg

Work done for pumping out water is equal to negative of change in its potential energy–

$$W = -\Delta P.E$$
$$W = -(PE_f - PE_i)$$
$$W = -(0 - mgh')$$
$$\Rightarrow \quad W = mgh'$$
$$\Rightarrow \quad W = 1000 \times 10 \times \frac{1}{2} = 5000\,J$$

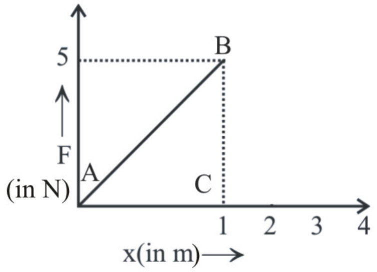
173. The force F acting on a particle moving in a straight line is shown in figure. What is the work done by the force on the particle in the 1st meter of the trajectory?



(a) 5 J (b) 10 J
(c) 15 J (d) 2.5 J

WB JEE 2009

Ans. (d) :



Work done by the force in first meter of trajectory = area of Δ ABC –

$$\Delta ABC = \frac{1}{2} \times \text{base} \times \text{height}$$
$$= \frac{1}{2} \times 1 \times 5$$
$$= 2.5\text{ J}$$

174. A 12 HP motor has to be operated 8h/day. How much will it cost at the rate of 50 paise/kWh in 10 days ?

(a) Rs 397 (b) Rs 375
(c) Rs 358 (d) Rs 350

UP CPMT-2011

Ans. (c) : Horse power can also defined as – work done per unit time.

Given, Power = 12 HP
Time = 8 Hrs/day
Cost = 50 paise/kWh
No. of days = 10

We know that,
1 HP =746 Watt

Therefore 12 HP = (12 × 746) Watt
Energy = Power × Time
Time = 8 hour = 8 × 3600 sec

For 10 days,
Energy =12 × 746 × 8 × 3600 × 10
= 2578176000 J

It is given that 50 paise/kWh costs in 10 days for the motor. So cost per unit energy

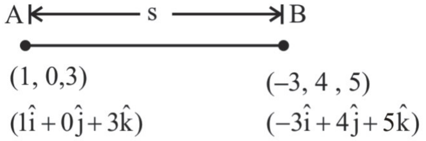
$$\text{cost} = \frac{0.5}{10^3 \times 3600}\,\text{Rs/J}$$
$$\text{Total cost} = 2578176000 \times \frac{0.5}{10^3 \times 3600}$$
$$= \text{Rs } 358$$

175. A particle moves from (1, 0, 3) to the point (-3, 4, 5) when a force $\vec{F} = (\hat{i} + 5\hat{k})$ acts on it. Amount of work done in Joules is

(a) 14 (b) 10
(c) 6 (d) 15

TS EAMCET (Engg.)-2016

Ans. (c) : According to question,


A
s
B
(1, 0,3)
(–3, 4 , 5)
$(1\hat{i} + 0\hat{j} + 3\hat{k})$
$(-3\hat{i} + 4\hat{j} + 5\hat{k})$

The displacement of the particle,

$$(s) = (-3\hat{i} + 4\hat{j} + 5\hat{k}) - (\hat{i} + 3\hat{k})$$
$$s = -4\hat{i} + 4\hat{j} + 2\hat{k}$$

Work done,

$$W = F.s$$
$$W = (\hat{i} + 5\hat{k}).(-4\hat{i} + 4\hat{j} + 2\hat{k})$$
$$W = -4 + 10$$
$$W = 6\text{ J}$$

176. A ball (initially at rest) is released from the top of a tower. The ratio of work done by the force of gravity in the first, second and third seconds is

(a) 1 : 3 : 5 (b) 1 : 4 : 16
(c) 1 : 9 : 25 (d) 1 : 2 :3

TS EAMCET (Engg.)-2015

@apna_pdf

Ans. (a) : We know that, distance travelled in n^{th} seconds as follows;

$$S_n = u + \frac{1}{2}g(2n-1) \text{ or } u + g\left(n - \frac{1}{2}\right)$$

Now, Height covered in n^{th} second,

$$h_n = u + g\left(n - \frac{1}{2}\right)$$

$$h_n = g\left(n - \frac{1}{2}\right) \qquad (u = 0)$$

Work done (W) = mgh

$\therefore$ Required ratio = $mgh_1 : mgh_2 : mgh_3 = h_1 : h_2 : h_3$

(for n = 1, 2, 3 second)

$$= g\left(1-\frac{1}{2}\right) : g\left(2-\frac{1}{2}\right) : g\left(3-\frac{1}{2}\right) = \frac{1}{2} : \frac{3}{2} : \frac{5}{2}$$

Ratio = 1 : 3 : 5

177. A body is acted upon by a force which is inversely proportional to the distance covered. The work done will be proportional to (s = distance covered)

(a) ln (s) (b) log(s)

(c) $\sqrt{s}$ (d) $\log\frac{1}{s}$

SRM JEE - 2008

Ans. (a) : According to question,

$$\text{Force} \propto \frac{1}{\text{Distance}}$$

$$F = \frac{k}{s} \qquad [k = \text{constant}]$$

Work done by moving a particle by small distance 'ds' is

$$dW = Fds \Rightarrow dW = \frac{k}{s}ds$$

Total work done will be, $\int dW = \int \frac{k}{s}ds = k\int \frac{1}{s}ds$

$$W = k\,ln(s)$$

$$W \propto ln(s)$$

178. A force $\vec{F} = (5\hat{i} + 3\hat{j})$ Newton displaces a body by $(2\hat{i} - \hat{j})$ metre. The work done by the force is:

(a) Zero (b) 12 joules

(c) 7 joules (d) 13 joules

MP PET -2013

Ans. (c) : Given that,

$$\vec{F} = (5\hat{i} + 3\hat{j}),\ \vec{s} = (2\hat{i} - \hat{j})$$

Work done,

$$W = \vec{F}\cdot\vec{s}$$

$$W = (5\hat{i} + 3\hat{j}).(2\hat{i} - \hat{j})$$

$$W = 5 \times 2 + 3 \times (-1)$$

$$W = 10 - 3$$

W = 7 Joules

179. Which one is correct?

(a) Joule = Coulomb × Volt

(b) Joule = Volt × Ampere

(c) Joule = Coulomb/Volt

(d) Volt = Joule × Coulomb

MP PET-2012

Ans. (a) : As we know,

$$\text{Potential}(V) = \frac{W}{q} = \frac{J}{C} = \text{Volt}$$

Volt = Joule/Coulomb

Joule = Coulomb × Volt

180. A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. The work done by the force of gravity during the time the particle goes up is

(a) –0.5 J (b) –1.25 J

(c) 1.25J (d) 0.5J

JIPMER-2009, 2014

Ans. (b) : Given, m = 100 g, u = 5 m/sec

From third equation of motion,

$$v^2 = u^2 - 2gh$$

$$0 = 25 - 2 \times 10h$$

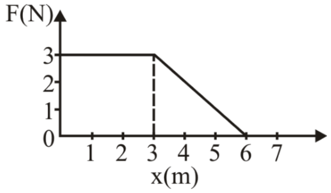
$$h = 1.25 \text{ m}$$

Work done by gravity (W_g) = – mgh

= – 0.1 × 10 × 1.25

= – 1.25 J

181. A force F acting on an object varies with distance x as shown here. The force is in Newton and distance is in meter. The work done by the force on moving the object form x = 0 to x = 6 m is



(a) 4.5 J (b) 13.5 J

(c) 9.0 J (d) 18.0 J

JIPMER- 2007

AIPMT-2005

Ans. (b) : We know that,

Work done in moving the object = Area under the curve

$$\int_0^x f.dx = (3)^2 + \left(\frac{1}{2} \times 3 \times 3\right)$$

$$W = 9 + \frac{9}{2}$$

$$W = \frac{27}{2}$$

W = 13.5 J

182. A force of 5N acts on a body initially at rest. If the instantaneous power due to the force at the end of the third second (t = 3 s) is 5W, then the mass of the body is

(a) 25 kg (b) 12.5 kg

(c) 15 kg (d) 7.5 kg

@apna_pdf

Ans. (c) : Given, force (F) = 5N, Power (P) = 5W
Time, t = 3 sec, Initial velocity (u) = 0
We know that –
Power (P) = F.v
$5 = 5 \times v$
v = 1 m/sec.
According to first law of motion,-
$v = u + at$
$1 = 0 + a \times 3$
$a = \frac{1}{3} m/s^2$
We know that,
F = ma
$5 = m \times \frac{1}{3}$
m = 15 kg

183. The velocity v reached by a car of mass m at certain distance from the starting point driven with constant power P is such that

(a) $v \propto \frac{3P}{m}$ (b) $v^2 \propto \frac{3P}{m}$
(c) $v^3 \propto \frac{3P}{m}$ (d) $v \propto \left(\frac{3P}{m}\right)^2$

AP EAMCET -2012

Ans. (c) : Power of car (P) = F × v

$$P = mav$$
$$= mv\frac{dv}{dt} \times \frac{dx}{dx}$$
$$P = mv^2\frac{dv}{dx}$$
$$Pdx = mv^2\,dv$$
$$\int_0^x Pdx = \int_0^v mv^2 dv$$
$$P[x]_0^x = m\left[\frac{v^3}{3}\right]_0^v$$
$$Px = \frac{m}{3}v^3$$
$$v^3 \propto \frac{3P}{m}$$

184. The work done in moving an object from origin to a point whose position vector is $r = 3\hat{i} + 2\hat{j} - 5\hat{k}$ by a force $F = 2\hat{i} - \hat{j} - \hat{k}$ is

(a) 1 unit (b) 9 units
(c) 13 units (d) 60 units

AP EAMCET -2013

Ans. (b) : Given, $\vec{F} = 2\hat{i} - \hat{j} - \hat{k}$

$$\vec{r} = 3\hat{i} + 2\hat{j} - 5\hat{k}$$

Work done = Force × Distance

$$W = \vec{F}.\vec{r}$$
$$W = \left(2\hat{i} - \hat{j} - \hat{k}\right).\left(3\hat{i} + 2\hat{j} - 5\hat{k}\right)$$
$$W = 6 - 2 + 5 = 9 \text{ unit}$$

185. A man of weight 50 kg carries an object to a height of 20 m in a time of 10s. The power used by the man in this process is 2000 W, then find the weight of the object carried by the man (take $g = 10\ ms^{-2}$)

(a) 100 kg (b) 25 kg
(c) 50 kg (d) 10 kg

AP EAMCET -2015

Ans. (c) : Given,
Mass of man (m_m) = 50 kg
Height (h) = 20 m
Time (t) = 10 sec
Power (P) = 2000W
Mass of object (m_o) = ?

$$P = \frac{W}{t} = \frac{Mgh}{t}$$
$$\because \quad M = m_m + m_o$$
$$2000 = \frac{(50 + m_o) \times 10 \times 20}{10}$$
$$m_o = 100 - 50 = 50 \text{ kg}$$

186. A body moves from a position $\vec{r}_1 = (2\hat{i} - 3\hat{j} - 4\hat{k})$ metre to a position $\vec{r}_2 = (3\hat{i} - 4\hat{j} + 5\hat{k})$ metre under the influence of a constant force $\vec{F} = (4\hat{i} + \hat{j} + 6\hat{k})$ newton. The work done by the force is

(a) 57 J (b) 58 J
(c) 59 J (d) 60 J

AMU-2009

Ans. (a) : Given that,

$$\vec{r}_1 = \left(2\hat{i} - 3\hat{j} - 4\hat{k}\right)$$
$$\vec{r}_2 = \left(3\hat{i} - 4\hat{j} + 5\hat{k}\right)$$
$$\vec{F} = \left(4\hat{i} + \hat{j} + 6\hat{k}\right)$$

Work done (W) = ?

So, Displacement vector $(\vec{s}) = \vec{r}_2 - \vec{r}_1$

$$\vec{s} = \left(3\hat{i} - 4\hat{j} + 5\hat{k}\right) - \left(2\hat{i} - 3\hat{j} - 4\hat{k}\right)$$
$$\vec{s} = \hat{i} - \hat{j} + 9\hat{k}$$

We know that,

Work done (W) = $\vec{F}.\vec{s}$

$$W = \vec{F}.\vec{s} = \left(4\hat{i} + \hat{j} + 6\hat{k}\right)\left(\hat{i} - \hat{j} + 9\hat{k}\right)$$
$$W = 4 - 1 + 54$$
$$W = 57 \text{ J}$$

187. The displacement x of a particle of mass 1.0 kg, moving in one dimension, under the action of a constant force is related to time t by the equation $t = \sqrt{x} - 3$ (in S.I. units). The work done by the force in the first 10 seconds, in Joules, is

(a) 640 J (b) 676 J
(c) 320 J (d) none of these.

AMU-2008

@apna_pdf

Ans. (c) : Given,

Mass (m) = 1kg

Equation, $t=\sqrt{x}-3$

Now,

$$\sqrt{x}=t+3$$

Squaring both sides,

$$x=(t+3)^2$$

Differentiating w.r.t 't', we get

$$v=\frac{dx}{dt}=2(t+3)$$

$$\text{At } t=10s,\ v_f=2(10+3)\Rightarrow 26\,m/s$$

$$\text{At } t=0s,\ v_i=2(0+3)=6\ m/s$$

From Work-Energy theorem,

$$W=\Delta K.E.=\frac{1}{2}m\left[v_f^2-v_i^2\right]$$

$$W=\frac{1}{2}\times 1\left[26^2-6^2\right]$$

$$W=\frac{1}{2}\times 1\times 640$$

$$W=320\ J$$

188. A 5 N force acts on a 15 kg body initially at rest. The work done by the force in the third second of its motion is (in joules) approximately equal to

(a) 9 (b) 15

(c) 4 (d) 20

AMU-2007

Ans. (c) : Given,

Force (F) = 5N

Mass (m) = 15kg

Initial velocity (u) = 0 m/s

We know that,

$$F=ma$$

$$a=\frac{F}{m}=\frac{5}{15}=\frac{1}{3}m/s^2$$

The formula for distance travelled in nth second is given by

$$s_{n^{th}}=u+a\left(n-\frac{1}{2}\right)$$

$$s_3=0+\frac{1}{3}\left(3-\frac{1}{2}\right)\qquad(\because t=3sec)$$

$$=\frac{1}{3}\times\frac{5}{2}=\frac{5}{6}m$$

$$s_3=\frac{5}{6}m$$

Work done (W) = F.s_3

$$W=5\times\frac{5}{6}$$

$$W=4.16\ J=4\ J$$

189. A man who weighs 670 N runs the first 7.0 m in 1.6 s, starting from rest and accelerating uniformly. What is the average power does the man generate during the 1.6 s time interval?

(a) 3.2 kW (b) 16 kW

(c) 0.9 kW (d) None of these

AMU-2016

Ans. (b) : Given, weights = 670 N

Displacement (s) = 7 m

Time (t) = 1.6 sec

Initial velocity (u) = 0

Power = ?

Now, from the equation of motion

$$s=ut+\frac{1}{2}at^2\qquad\text{.....(i)}$$

Substituting the value in equation (i),

$$7=0\times 1.6+\frac{1}{2}\times a\times(1.6)^2$$

$$a=\frac{7\times 2}{(1.6)^2}\qquad\text{.....(ii)}$$

For final velocity, we have

$$v=u+at$$

$$v=0+\frac{7\times 2}{1.6\times 1.6}\times 1.6$$

$$v=\frac{14}{1.6}$$

From Work – Energy theorem, we have

$$\text{Work done}=\Delta K.E=\frac{1}{2}mv^2$$

$$\text{Then, Power (P)}=\frac{\text{Work done}}{\text{Time}}$$

$$=\frac{1}{2}\times\frac{670\times(14)^2}{1.6\times(1.6)^2}$$

=16030.27 watt

Now, 16030.27 watt is equivalent to 16 kW.

190. A force $\vec{F}=-(y\hat{i}+x\hat{j})$ acts on a particle moving in X-Y plane. Start in from the origin, the particle is taken along the positive X-axis to the point (2a, 2a). The total work done on the particle is

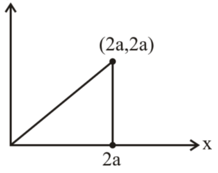
(a) $-4a^2$ (b) $-2a^2$

(c) $4a^2$ (d) $2a^2$

AMU-2014

Ans. (a) : Given,

$$\text{Force}(\vec{F})=-(y\hat{i}+x\hat{j})$$



From graph, x = y …(i)

According to x - y graph,

@apna_pdf

Net Work done by the applied force $(W)=\int \vec{F}\cdot d\vec{s}$

$$W=\int -\left(y\hat{i}+x\hat{j}\right)\cdot\left(dx\hat{i}+dy\hat{j}\right)$$

$$W=-\int ydx-\int xdy$$

$$W=-\int_0^{2a} xdx-\int_0^{2a} ydy \qquad [\therefore x=y]$$

$$W=-\left[\frac{x^2}{2}\right]_0^{2a}-\left[\frac{y^2}{2}\right]_0^{2a}$$

$$W=-\left(\frac{4a^2}{2}-0\right)-\left(\frac{4a^2}{2}-0\right)$$

$$W=-4a^2$$

191. The cathode of photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the photocurrent before and after the above change is I_1 and I_2 then

(a) $I_1 = I_2$ (b) $I_2 > I_1$

(c) $I_1 > I_2$ (d) $I_2 = I_1/2.0$

AMU-2004

Ans. (a) : The work function will have no effect on photoelectric current.

The photo current is independent of the value of work function and it is proportional to the intensity of incident light.

Therefore, there will be no change in the intensity of light.

$\therefore I_1 = I_2$

192. Under the action of a force, a 2 kg body moves such that its position x as function of time is given by $x = t^3/3$. The work done by the force in first three seconds is

(a) 8 J (b) 81 J

(c) 800 J (d) 48 J

AMU-2004

Ans. (b) : Given that,

Mass (m) = 2 kg

and equation, $x=\frac{t^3}{3}$

Differentiating with respect to't',

$$\frac{dx}{dt}=v=\frac{3t^2}{3}=t^2 \text{ .... (i)}$$

Differentiating with respect to 't'again,

$$\frac{d^2x}{dt^2}=a=2t$$

We know that,

$F = ma$

$F = 2 \times 2t = 4t$ .... (ii)

Now,

Work done $(dW) = F.dx$

Integrating both side,

$$\int dW=\int 4tdx \text{ .... (ii)}$$

$$W=\int_0^3 4t^3dt \quad \{dx=t^2\,dt\}$$

$$W=\left[4\times\frac{t^4}{4}\right]_0^3 \quad \text{from (i)}$$

$$=\left[t^4\right]_0^3$$

$$W=\left[\left(3^4\right)-(0)\right]$$

$W = 81$ J

193. A 60 kg man runs up a staircase in 12 second while a 50 kg man runs up the same staircase in 11 seconds. The ratio of the rate of doing their work will be

(a) 10 : 11 (b) 11 : 10

(c) 6 : 5 (d) 5 : 6

AMU-2001

Ans. (b) : Given data,

$m_1 = 60$ kg and $t_1 = 12$ s

$m_2 = 50$ kg and $t_2 = 11$ s

We know that,

$$\text{Power}=\frac{\text{Work done}}{\text{time}}=\frac{mgh}{t}$$

(Rate of work = Power)

Then,

$$P_1=\frac{60\times g\times h}{12}$$

and $P_2=\frac{50\times g\times h}{11}$

So, $$\frac{P_1}{P_2}=\frac{60\times g\times h}{12}\times\frac{11}{50\times g\times h}=\frac{60\times 11}{12\times 50}$$

$$\frac{P_1}{P_2}=\frac{11}{10}$$

$$P_1:P_2=11:10$$

194. A particle is moving in translatory motion. If momentum of the particle decreases by 10%, kinetic energy will decrease by

(a) 10% (b) 5%

(c) 20% (d) 19%

UPSEE - 2016

Ans. (d) : We know that,

$$K=\frac{p^2}{2m}$$

$$p=\sqrt{2mK}$$

$$p\propto\sqrt{K}$$

Now, $$p_2=p_1-\frac{10\times p_1}{100}$$

$$p_2=\frac{90p_1}{100}$$

$$\frac{p_1}{p_2}=\frac{100}{90}$$

So,

$$\frac{p_1}{p_2}=\sqrt{\frac{K_1}{K_2}}$$

@apna_pdf

$$\frac{100}{90}=\sqrt{\frac{K_1}{K_2}}$$

$$\left(\frac{100}{90}\right)^2=\frac{K_1}{K_2}$$

$$\frac{100}{81}=\frac{K_1}{K_2}$$

$$\frac{K_2}{K_1}=\frac{81}{100}$$

Then,

$$1-\frac{K_2}{K_1}=1-\frac{81}{100}$$

$$\frac{K_1-K_2}{K_1}=\frac{100-81}{100}$$

Therefore,

$$\frac{K_1-K_2}{K_1}\times100=\frac{19}{100}\times100 \;=19\ \%$$

195. How much water a pump of 2 kW can raise in one minute to a height of 10 m? (Take g = 10m/s^2)

(a) 1000 L (b) 1200 L

(c) 100 L (d) 2000 L

AIPMT- 1990

Ans. (b) : Given data,

Power (P) = 2 kW = 2× 10^3 W

Time (t) = 1 minute = 60 sec

Height (h) = 10m

g = 10 m/s^2

Density of water (ρ) = 1000 kg/m^3

We know that,

$$\text{Power }(P)=\frac{\text{Work done}}{\text{time}}=\frac{mgh}{t}$$

$$m=\frac{P\times t}{gh}$$

$$m=\frac{2\times10^3\times60}{10\times10}=1200\text{ kg}$$

Then,

$$\text{Volume}(V)=\frac{\text{Mass}}{\text{Density}}$$

$$V=\frac{1200}{1000} \qquad (\therefore 1\text{m}^3=1000\,l)$$

V = 1.2 m^3 or V = 1200 L

196. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine? (Take g = 10m/s^2)

(a) 8.1 kW (b) 10.2 kW

(c) 12.3 kW (d) 7.0 kW

AIPMT- 2008

Ans. (a) : Given data,

Mass of water falling/second = 15 kg/s

h = 60 m,

g = 10m/s^2

Loss = 10% i.e. 90% is used

$$\text{Power generated }(P)=\frac{mgh}{t}\times\frac{90}{100}$$

$$\text{Power generated }(P)=15\times10\times60\times\frac{90}{100}$$

= 8.1 kW

197. A body of mass 1 kg begins to move under the action of a time dependent force $\mathbf{F}=\left(2t\hat{i}+3t^2\hat{j}\right)\mathbf{N}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along X and Y axes. What power will be developed by the force at the time (t)?

(a) $(2t^2+4t^4)$W (b) $(2t^3+3t^4)$W

(c) $(2t^3+3t^5)$W (d) $(2t+3t^3)$W

NEET- 2016

Ans. (c) : Given that,

Mass (m) = 1 kg

And equation, $(\vec{F})=2t\hat{i}+3t^2\hat{j}$

We know,

$$\vec{F}=m\vec{a}=m\frac{dv}{dt}$$

$$\vec{a}=\frac{F}{m}=\frac{2t\hat{i}+3t^2\hat{j}}{1}$$

$$\vec{a}=2t\hat{i}+3t^2\hat{j}$$

$$\frac{d\vec{v}}{dt}=2t\hat{i}+3t^2\hat{j} \qquad \left(\therefore \vec{a}=\frac{d\vec{v}}{dt}\right)$$

$$\int d\vec{v}=\int_0^t\left(2t\hat{i}+3t^2\hat{j}\right)dt$$

$$\vec{v}=\left[\frac{2t^2\hat{i}}{2}+\frac{3t^3\hat{j}}{3}\right]_0^t$$

$$\vec{v}=t^2\hat{i}+t^3\hat{j}$$

We know,

$$\text{Power }(P)=\vec{F}.\vec{v}$$

$$=\left(2t\hat{i}+3t^2\hat{j}\right)\left(t^2\hat{i}+t^3\hat{j}\right)$$

P = $(2t^3+3t^5)$ W

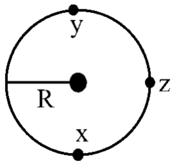
198. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

(a) $\sqrt{2gR}$ (b) $\sqrt{3gR}$

(c) $\sqrt{5gR}$ (d) $\sqrt{gR}$

NEET- 2016

Ans. (c) :



To just complete the circle, at highest point, T = 0

@apna_pdf

$$\frac{mv_y^2}{R} = mg \qquad .....(i)$$

Applying law of conservation of energy at top and bottom point

$$\frac{1}{2}mv_x^2 = mg \times 2R + \frac{1}{2}mv_y^2 \qquad ....(ii)$$

$$\frac{1}{2}mv_x^2 = 2mgR + \frac{1}{2}mgR \qquad \text{From eq}^n\text{. (i)}$$

$$\frac{1}{2}mv_x^2 = \frac{5}{2}mgR$$

$$v_x^2 = 5gR$$

$$v_x = \sqrt{5gR}$$

199. An engine pumps water through a hose pipe. Water passes through the pipe and leaves it with a velocity of 2ms^{-1}. The mass per unit length of water in the pipe is 100 kg m^{-1}. What is the power of the engine?

(a) 400 W
(b) 200 W
(c) 100 W
(d) 800 W

AIPMT- 2010

Ans. (d) : Given that,

$$v = 2\text{m/sec}, \ \frac{m}{l} = 100\,\text{kg/m}, \ p = ?$$

We know that,

$$F = \frac{\Delta p}{\Delta t} = \frac{mv}{t} \qquad ....(i)$$

Where, v = velocity

P = momentum

∵ P = F.v

Putting the value of F from equation (i), we get

$$P = \frac{mv.v}{t} = \frac{mv^2}{t}$$

$$P = \left(\frac{\rho.A.l}{t}\right)v^2 \qquad \left(\begin{array}{l}\because \rho = \dfrac{m}{V} \\ m = \rho.V \\ m = \rho(A.l)\end{array}\right)$$

$$P = \rho.A.\left(\frac{l}{t}\right)v^2$$

$$P = \rho A v^3$$

$$P = \left(\frac{m \times A}{A \times l}\right)v^3$$

$$P = \left(\frac{m}{l}\right)v^3$$

$$P = 100 \times (2)^3$$

$$P = 800 \text{ W}$$

200. A bullet of mass 10 g leaves a rifle at an initial velocity of 1000 m/s and strikes the earth at the same level with a velocity of 500 m/s. The work done in joule to overcome the resistance of air will be

(a) 375
(b) 3750
(c) 5000
(d) 500

AIPMT- 1989

Ans. (b) : Given,

Mass of bullet (m) = 10 g = 0.01 kg

Initial velocity of bullet (v_1) = 1000 m/s

Velocity of bullet at striking time (v_2) = 500 m/s

Work done = ?

$$\text{Initial Kinetic energy (KE)} = \frac{1}{2} \times m \times v_1^2$$

$$= \frac{1}{2} \times 0.01 \times 10^6$$

$$= 5000 \text{ Joule}$$

$$\text{Final Kinetic energy} = \frac{1}{2} \times m \times v_2^2$$

$$= 0.5 \times 0.01 \times 25 \times 10^4$$

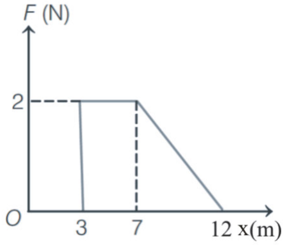
$$= 1250 \text{ Joule}$$

Applying the work energy theorem–

Work done in overcoming the air resistance (W) = Loss in energy

$$W = 5000 - 1250 = 3750 \text{ J}$$

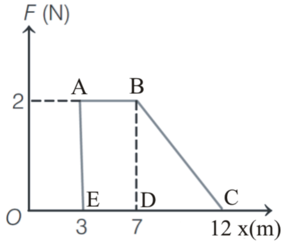
201. Force F on a particle moving in a straight line varies with distance d as shown in the figure. The work done on the particle during its displacement of 12 m is



(a) 21 J
(b) 26 J
(c) 13 J
(d) 18 J

AIPMT- 2011

Ans. (c) : Area under F-x graph,



Work done (W) = Area of ABDE+Area BDC

$$= 2 \times (7-3) + \frac{1}{2} \times (12-7) \times 2$$

$$= 2 \times 4 + \frac{1}{2} \times 5 \times 2$$

$$= 8 + 5$$

$$= 13 \text{ J}$$

@apna_pdf

202. A uniform force of $\left(3\hat{i}+\hat{j}\right)$ N acts on a particle of mass 2 kg. Hence, the particle is displaced from position $\left(2\hat{i}+\hat{k}\right)$m to position $\left(4\hat{i}+3\hat{j}-\hat{k}\right)$m. The work done by the force on the particle is

(a) 9 J (b) 6 J
(c) 13 J (d) 15 J

NEET- 2013

Ans. (a) : Given,

$$F=3\hat{i}+\hat{j} \qquad m=2\text{ kg}$$

$$\vec{r}_1=2\hat{i}+\hat{k} \qquad \vec{r}_2=4\hat{i}+3\hat{j}-\hat{k}$$

$$\therefore \quad s=\vec{r}_2-\vec{r}_1$$

$$=\left(4\hat{i}+3\hat{j}-\hat{k}\right)-\left(2\hat{i}+\hat{k}\right)$$

$$s=2\hat{i}+3\hat{j}-2\hat{k}$$

Work done (W) = $\vec{F}.\vec{s}$

$$=\left(3\hat{i}+\hat{j}\right)\cdot\left(2\hat{i}+3\hat{j}-2\hat{k}\right)$$

$$=6+3+0 \qquad \left\{\begin{matrix}\hat{i}\cdot\hat{i}=\hat{j}\cdot\hat{j}=\hat{k}\cdot\hat{k}=1\\ \hat{i}\cdot\hat{j}=\hat{j}\cdot\hat{k}=\hat{k}\cdot\hat{i}=0\end{matrix}\right\}$$

$$W=9\text{ J}$$

203. A particle moves from a point $\left(-2\hat{i}+5\hat{j}\right)$ to $\left(4\hat{j}+3\hat{k}\right)$ when a force of $\left(4\hat{i}+3\hat{j}\right)$ N is applied. How much work has been done by the force?

(a) 8 J (b) 11 J
(c) 5 J (d) 2 J

NEET- 2016

Ans. (c) : Given,

$$\vec{r}_1=-2\hat{i}+5\hat{j}$$

$$\vec{r}_2=4\hat{j}+3\hat{k}$$

$$\vec{F}=4\hat{i}+3\hat{j}$$

Work done (W) = $\vec{F}.\vec{s}$

$$=\left(4\hat{i}+3\hat{j}\right)\cdot\left(\vec{r}_2-\vec{r}_1\right)$$

$$=\left(4\hat{i}+3\hat{j}\right)\cdot\left[\left(4\hat{j}+3\hat{k}\right)-\left(-2\hat{i}+5\hat{j}\right)\right]$$

$$=\left(4\hat{i}+3\hat{j}\right)\cdot\left(2\hat{i}-\hat{j}+3\hat{k}\right)$$

$$=8-3 \qquad \left\{\begin{matrix}\hat{i}\cdot\hat{i}=\hat{j}\cdot\hat{j}=\hat{k}\cdot\hat{k}=1\\ \hat{i}\cdot\hat{j}=\hat{j}\cdot\hat{k}=\hat{k}\cdot\hat{i}=0\end{matrix}\right\}$$

$$W=5\text{ J}$$

204. Displacement of a body is $(5\hat{i}+3\hat{j}-4\hat{k})$ m when a force $(6\hat{i}+6\hat{j}+4\hat{k})$ N acts for 5 s. The power in watt is

(a) 16 (b) 9.6
(c) 6.4 (d) 3.2

AP EAMCET(Medical)-2012

Ans. (c) : Given that,

$$\vec{F}=(6\hat{i}+6\hat{j}+4\hat{k})\text{ N}$$

$$\vec{r}=(5\hat{i}+3\hat{j}-4\hat{k})\text{ m}, \qquad t=5\text{ s}$$

Work done, W = $\int F.dr = F.r$

$$W=\left(6\hat{i}+6\hat{j}+4\hat{k}\right)\cdot\left(5\hat{i}+3\hat{j}-4\hat{k}\right)$$

$$=30+18-16$$

$$W=32\text{ J}$$

We know that,

$$\text{Power }(P)=\frac{\text{Work done}}{\text{Time}}$$

$$P=\frac{32}{5}=6.4\text{ watt}$$

205. Force acting on a particle is $(2\hat{i}+3\hat{j})$ N. Work done by this force is zero. When a particle is moved along the line 3y+kx = 5, then the value of k is

(a) 8 (b) 6
(c) 4 (d) 2

AP EMCET(Medical)-2011

Ans. (d) : Given,

$$F=(2i+3j)\text{ N} \Rightarrow \text{Slope, } m_1=\frac{3}{2}$$

And $\qquad 3y+kx=5$

$$y=-\frac{k}{3}x+\frac{5}{3} \qquad \text{....(i)}$$

Comparing eq^n. (i) with y = mx+c, we get

$$\text{slope, } m_2=-\frac{k}{3}$$

$\because$ Work done = 0

$\Rightarrow$ $\vec{F}\perp\vec{S}$

$\Rightarrow$ $m_1.m_2=-1$

$$\frac{3}{2}\times\frac{-k}{3}=-1$$

$\therefore$ k = 2

206. A box of mass 50 kg is pulled up on an inclined plane of 12m long and 2m high by a constant force of 100 N from rest. It acquires a velocity of 2 m/s, when it reaches the top of the plane. The work done against friction in joule is: (g=10m/s^2)

(a) 50 (b) 100
(c) 150 (d) 200

AP EAMCET(Medical)-2002

Ans. (b) : Given that,

m = 50 kg
v = 2 m/s
l = 12 m
h = 2 m
F = 100 N
W_f = ?

@apna_pdf

Total work done by pulling is equal to the sum of work done due to potential energy, work done due to kinetic energy and work done due to friction.

So,

Total work = $W_{(P.E.)} + W_{(K.E.)} + W_{(friction)}$

$$W = mgh + \frac{1}{2}mv^2 + W_f$$

$$Fl = mgh + \frac{1}{2}mv^2 + W_f$$

$$100 \times 12 = 50 \times 10 \times 2 + \frac{1}{2} \times 50 \times 2^2 + W_f$$

$$1200 = 1000 + 100 + W_f$$

$$W_f = 100 \text{ J}$$

207. A force $\vec{F} = 3\hat{i} + c\hat{j} + 2\hat{k}$ acting on a particle causes a displacement $\vec{S} = -4\hat{i} + 2\hat{j} - 3\hat{k}$ in its own direction. If the work done is 6 J, the value of c is:

(a) zero (b) 1

(c) 12 (d) 6

AP EAMCET(Medical)-1997

Ans. (c) : Given,

$$\vec{F} = \left(3\hat{i} + c\hat{j} + 2\hat{k}\right)\text{N}$$

$$\vec{S} = \left(-4\hat{i} + 2\hat{j} - 3\hat{k}\right)\text{m}$$

$$\text{Workdone}\,(W) = \vec{F}.\vec{S}$$

$$W = \left(3\hat{i} + c\hat{j} + 2\hat{k}\right)\cdot\left(-4\hat{i} + 2\hat{j} - 3\hat{k}\right)$$

$$6 = 3\,(-4) + c\,(2) + 2\,(-3)$$

$$6 = -12 + 2c - 6$$

$$2c = 24$$

$\therefore$ $c = 12$

208. The work done on a particle moving round a horizontal circular path of radius 2 with uniform speed v under a centripetal force F is equal to

(a) mvr (b) 0

(c) $m\omega r^2$ (d) $\frac{mv}{r}$

EAMCET-1992

Ans. (b) : We have, work done,

$$W = \vec{F}.\vec{s}$$

$$W = F.s \cos\theta$$

Force in uniform circular motion is always perpendicular to the displacement. Hence, the angle between F and s is always 90°.

After putting the value of θ

Work done, W = 0

209. A 1.0 HP motor pumps out water from a well of 30 m and fills a water tank of volume 2238 L at a height of 10 m from the ground. The running time of the motor to fill the empty water tank is

(a) 5 min (b) 10 min

(c) 15 min (d) 20 min

EAMCET-2000

Ans. (d) : Given,

Power (P) = 1 HP = 746 W

Depth of well (d) = 30m

Height (H) = 10 m

Volume (V) = 2238 L = 2238×10^{-3} m^3

Total height of lifted water (h) = 30 + 10 = 40m

Now, Mass of water, m = ρ × V

$$m = 1 \times 10^3 \times 2238 \times 10^{-3} \quad \left(\begin{matrix}\text{Density of water} \\ \text{is } 1 \times 10^3 \text{ kg/m}^3\end{matrix}\right)$$

$$m = 2238 \text{ kg}$$

We know, Work done (W) = mgh

$$\text{Power (P)} = \frac{\text{Work done}}{\text{time}}$$

$$\therefore \quad t = \frac{mgh}{P}$$

$$t = \frac{2238 \times 9.8 \times 40}{746} = 1176 \text{ s}$$

$$t = \frac{1176}{60} \text{ min}$$

$$t = 19.6 \,\square\, 20 \text{ min}$$

210. A force applied by an engine on a train of mass 2.05×10^6 kg changes its velocity from 5 ms^{-1} to 25 ms^{-1} in 5 min. The power of the engine is

(a) 1.025 MW (b) 2.05 MW

(c) 5 MW (d) 6 MW

EAMCET-2001

Ans. (b) : Given, mass of train (m) = 2.05×10^6 kg

u= 5 m/s and v = 25 m/s

Time taken (t) = 5 min

t = 5 × 60 = 300 sec

From first law of motion,

$$v = u + at$$

$$a = \frac{v - u}{t}$$

$$a = \frac{25 - 5}{300}$$

$$a = \frac{1}{15} \text{ m/sec}^2$$

By using 3rd equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$(25)^2 - (5)^2 = 2 \times \frac{1}{15} \times s$$

$$s = 4500 \text{ m}$$

Work done (W) = m.a.s

$$W = \frac{2.05 \times 10^6 \times 4500}{15}$$

$$\text{Power}(P) = \frac{\text{Work done}}{\text{time}}$$

$$P = \frac{2.05 \times 10^6 \times 1 \times 4500}{15 \times 300}$$

$$P = 2.05 \times 10^6 \text{ W}$$

$$P = 2.05 \text{ MW}$$

@apna_pdf

211. A body of mass 6 kg is under a force which causes displacement in it given by $s = \frac{t^2}{4}$ metre where t is time. The work done by the force in 2s is

(a) 12 J (b) 9 J (c) 6 J (d) 3 J

EAMCET-2001

Ans. (d) : Given, mass of a body (m) = 6 kg

Displacement $(s) = \frac{t^2}{4}$ meter

So, velocity, $v = \frac{ds}{dt}$

$$v = \frac{d(t^2/4)}{dt} = \frac{2t}{4}$$

$$v = \frac{t}{2} \text{m/sec}$$

Acceleration, $a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{t}{2}\right)$

$$a = \frac{1}{2} \text{ m/s}^2$$

Work done $(W) = \int F.ds$

$$W = \int m.a.ds$$

$$W = \int m.\frac{1}{2}.\frac{t^2}{4}dt$$

$$W = \int_0^2 6 \times \frac{1}{2} \times \frac{t^2}{4} dt, \qquad W = \frac{3}{4}\left[t^2\right]_0^2$$

$$W = \frac{3}{4}\left(2^2 - 0^2\right), \qquad W = 3J$$

212. A bullet of mass 10 g is fired horizontally with a velocity 1000 ms^{-1} from a rifle situated at a height 50 m above the ground. If the bullet reaches the ground with a velocity 500 ms^{-1}, the work done against air resistance in the trajectory of the bullet is (g = 10 ms^{-2})

(a) 5005 J (b) 3755 J

(c) 3750 J (d) 17.5 J

AP EAMCET-2006

Ans. (b) : Given, mass of bullet (m) = 10g = 10^{-2} kg

Initial velocity (u) = 1000 ms^{-1}

Final velocity (v) = 500 ms^{-1}

height of elevation (h) = 50m

Energy lost due to air resistance is the energy,

$$W = \left(mgh + \frac{1}{2}mu^2\right) - \frac{1}{2}mv^2$$

$$W = \frac{1}{2}m\left(u^2 - v^2\right) + mgh$$

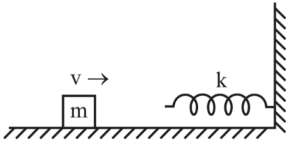
$$W = \frac{1}{2} \times 10^{-2} \times \left[(1000)^2 - (500)^2\right] + 10^{-2} \times 10 \times 50$$

$$W = \frac{1}{2} \times 10^{-2} \times 750000 + 10^{-2} \times 500$$

$$W = \frac{1}{2} \times 7500 + 5 = 3750 + 5$$

$$W = 3755 \text{ J}$$

213. A block of mass m = 25 kg sliding on a smooth horizontal surface with a velocity v = 3 ms^{-1} meets the spring of spring constant k = 100 Nm^{-1} fixed at one end as shown in figure. The maximum compression of the spring and velocity of block as it returns to the original position respectively are



(a) 1.5 m, –3 ms^{-1} (b) 1.5 m, 0.01 ms^{-1}

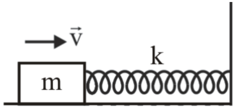
(c) 1.0 m, 3 ms^{-1} (d) 0.5 m, 2 ms^{-1}

AP EAMCET-2007

Ans. (a) : Given, mass of block (m) = 25kg

Sliding velocity (v) = 3ms^{-1}

Spring constant (k) = 100 Nm^{-1}



According to law of conservation of energy,

$$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

Where, x = compression of spring

$$x = \sqrt{\left(\frac{mv^2}{k}\right)}$$

$$x = \sqrt{\frac{25 \times (3)^2}{100}} = \sqrt{\frac{9}{4}} = \frac{3}{2}$$

$$x = 1.5\text{m}$$

When the block is returns to the original position again the potential energy is converted into the kinetic energy. Hence, velocity of block is same as before but sign changes because it return to mean position.

So, v = –3 m/sec

214. The machine gun fires 240 bullet/min. If the mass of each bullet is 10 g and the velocity of the bullet is 600 ms^{-1}, the power (in kW) of the gun is

(a) 43200 (b) 432

(c) 72 (d) 7.2

EAMCET-2005

Ans. (d): Given, mass of each bullet (m)=10gm=10^{-2}kg

Fire number of bullets (N) = 240 bullet/min, velocity (v) = 600 m/s, time (t) = 60 s

So, $\text{Power}(P) = \frac{\text{Work done}(W)}{\text{Time taken}}$

$$P = \frac{N \times \text{K.E of bullets}}{t}$$

$$P = \frac{240 \times \frac{1}{2} \times 10^{-2} \times (600)^2}{60}$$

$$P = 2 \times 10^{-2} \times (600)^2$$

$$P = 7.2 \times 10^3\text{W}$$

$$P = 7.2 \text{ kW}$$

@apna_pdf

(b) Potential and Kinetic Energy

215. A 0.4 kg mass takes 8 s to reach ground when dropped from a certain height 'P' above surface of earth. The loss of potential energy in the last second of fall is ----- J. (Take g = 10m/s^2)

JEE Main-29.01.2023, Shift-I

Ans. (300) : Given, mass (m) = 0.4 kg and time (t) = 8sec

Loss in potential energy = Gain in kinetic energy

Velocity after 8sec, $v_2 = 10 \times 8 = 80$ m/s

Velocity after 7 sec, $v_1 = 10 \times 7 = 70$ m/s

In last second gain in K.E.= $\frac{1}{2}m(v_2^2 - v_1^2)$

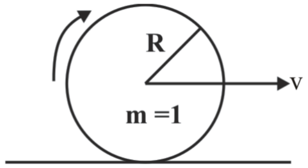
$$= \frac{1}{2} \times 0.4(6400 - 4900) = 300\,\text{J}$$

Hence, gain in potential energy = 300J

216. A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is 7 ×10^{-3} J. The speed of the centre of mass of the sphere is ______ cm s^{-1}

JEE Main-31.01.2023, Shift-I

Ans. (10) : Given, mass = 1 kg and kinetic energy (K.E.) = 7 × 10^{-3} J



We know that, K.E. = $\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

$$\text{K.E.} = \frac{1}{2}\left(\frac{2}{5}mR^2\right)\omega^2 + \frac{1}{2}mv^2$$

$$\text{K.E.} = \frac{1}{5}mv^2 + \frac{1}{2}mv^2 \quad (\because v = R\omega)$$

$$\text{K.E.} = \frac{(2+5)mv^2}{10}$$

$$7 \times 10^{-3} = \frac{7}{10} \times 1 \times v^2$$

$$v^2 = \sqrt{10^{-2}}$$

$$v = \frac{1}{10}\,\text{m/s} = 10\,\text{cm/s}$$

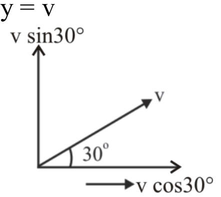
217. A stone is projected at angle 30º to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be-

(a) 4 : 1
(b) 1 : 2
(c) 4 : 3
(d) 1 : 4

JEE Main-29.01.2023, Shift-I

Ans. (c) : Given that, projected angle (θ) = 30°

Let, initial velocity = v



Velocity of horizontal (v_1) = v cos30º = $\frac{\sqrt{3}\,v}{2}$

Kinetic energy at the height point of flight–

$$\text{K.E}_1 = \frac{1}{2}m\left(\frac{\sqrt{3}v}{2}\right)^2 = \frac{3mv^2}{8} \quad .....(i)$$

Kinetic energy of the stone at point of projection,

Therefore, K.E$_2$ = $\frac{1}{2}mv^2$ .....(ii)

Dividing equation (i) by equation (ii), we get–

$$\frac{\text{K.E}_2}{\text{K.E}_1} = \frac{\frac{1}{2}mv^2}{\frac{3}{8}mv^2} = \frac{4}{3}$$

Hence, K.E$_2$: K.E$_1$ = 4 : 3

218. A lift of mass M = 500 kg is descending with speed of 2 ms^{-1}. Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of 2 ms^{-2}. The kinetic energy of the lift at the end of fall through to a distance of 6 m will be _____ kJ.

JEE Main-31.01.2023, Shift-I

Ans. (7) : Given that, u = 2 m/s, a = 2m/s^2, s = 6 m

We know that, $v^2 = u^2 + 2\,as$

$$v = \sqrt{4 + 2 \times 2 \times 6}$$

$$v = \sqrt{28}\,\text{m/s}$$

Then, kinetic energy (K.E,) = $\frac{1}{2}mv^2$

$$\text{K.E.} = \frac{1}{2} \times 500 \times \left(\sqrt{28}\right)^2$$

$$\text{K.E.} = \frac{1}{2} \times 500 \times 28$$

$$\text{K.E.} = 500 \times 14 = 7000\text{J}$$

$$\text{K.E.} = 7\,\text{kJ}$$

219. Two masses of 1 gram and 4 gram are moving with equal kinetic energy. The ratio of the magnitudes of their momenta is

(a) 1:16
(b) 1:2
(c) 2:1
(d) 4:1

MHT-CET 2020
Haryana CEE-1996
KCET-1999
Odisha JEE-2003
DCE-2009, 2004
AIEEE-2002
BHU-2004

@apna_pdf

Ans. (b) : Given, $m_1 = 1$ gm , $m_2 = 4$ gm

We know that, $\text{K.E.} = \frac{1}{2}mv^2$

$$\text{K.E.} = \frac{1}{2}m.\frac{p^2}{m^2} \quad (\because p = mv \Rightarrow v = \frac{p}{m})$$

$$= \frac{1}{2}\frac{p^2}{m}$$

According to question both mass have same kinetic energy,

So, $\frac{1}{2}\frac{p_1^2}{m_1} = \frac{1}{2}\frac{p_2^2}{m_2}$

$$\frac{p_1^2}{1} = \frac{p_2^2}{4}$$

$$\therefore \quad \frac{p_1}{p_2} = \frac{1}{2}$$

220. If we increase kinetic energy of a body 300%, then percent increase in its momentum is

(a) 50% (b) 300%
(c) 100% (d) 150%

JIPMER-2014, 1978
CG PET-2005
AFMC-1993
RPET-1999, 1996
AIPMT-2002
WB JEE-2009
DPMT-2000

Ans. (c) : We know that,

Momentum (p) = $\sqrt{2mK}$ (K = kinetic energy)

$$K = \frac{p^2}{2m}$$

If kinetic energy of a body is increased by 300%, let its momentum becomes p'.

$$K' = K + \frac{300}{100}K = 4K \qquad \begin{bmatrix}\text{Initial K.E.} = K \\ \text{Final K.E.} = K'\end{bmatrix}$$

Therefore, momentum is given by.

$$p' = \sqrt{2m \times K'}$$

$$p' = \sqrt{2m \times 4K} \qquad \begin{bmatrix}\text{Initial momentum} = p \\ \text{Final momentum} = p'\end{bmatrix}$$

$$= 2\sqrt{2mK}$$

$$p' = 2p$$

∴ Percentage change in momentum.

$$\frac{\Delta p}{p} \times 100 = \frac{p' - p}{p} \times 100$$

$$= \left(\frac{p'}{p} - 1\right) \times 100 \quad = \left(\frac{2p}{p} - 1\right) \times 100 \quad = 100\%$$

Hence, momentum will increase by 100%.

221. If the momentum of a body moving in a straight line is increased by 50%, the percent increase in its kinetic energy will be

(a) 75 % (b) 100 %
(c) 125 % (d) 150%

JEE main 29.07.2022 Shift-II
Kerala CEE - 2016
AIPMT - 1995
CG PET- 2005

Ans. (c) : Kinetic energy $(KE)_1 = \frac{p^2}{2m}$

When momentum is increased by 50% then

$$p' = 1.5p$$

$$\therefore \text{ Kinetic energy } (KE)_2 = \frac{(1.5p)^2}{2m} = \frac{2.25p^2}{2m}$$

Increase in kinetic energy = $(KE)_2 - (KE)_1$

$$= \frac{2.25p^2}{2m} - \frac{p^2}{2m} = \frac{1.25p^2}{2m}$$

$$\therefore \text{ \% increase in kinetic energy} = \frac{(KE)_2 - (KE)_1}{(KE)_1} \times 100$$

$$= \frac{\frac{1.25p^2}{2m}}{\frac{p^2}{2m}} \times 100$$

$$= 125\%$$

222. If the linear momentum of a body is increased by 50%, then the kinetic energy of that body increases by :

(a) 100% (b) 125%
(c) 225% (d) 25%

TS EAMCET 29.09.2020 Shift - I
Karnataka CET-2010
UPSEE -2008
BCECE - 2004

Ans. (b) : Relation between kinetic energy and momentum

$$\text{K.E.} = \frac{p^2}{2m} \qquad \text{.....(i)}$$

According to the question momentum is increased by 50%

So, new momentum becomes

$$p' = p + 50\% \text{ of } p$$

$$p' = p + p \times \frac{50}{100}$$

$$p' = 1.5\ p$$

Therefore new kinetic energy,

$$\text{K.E.}' = \frac{(1.5p)^2}{2m}$$

$$\text{K.E.}' = \frac{2.25p^2}{2m}$$

Change in kinetic energy becomes.

$$= \text{K.E.}' - \text{K.E.}$$

$$= \frac{2.25p^2}{2m} - \frac{p^2}{2m}$$

$$= \frac{p^2}{2m}(2.25 - 1) \quad = \frac{p^2}{2m}(1.25)$$

$$= 1.25 \text{ K.E.} \qquad [\because \text{From equation (i)}]$$

$$\text{Increased in percentage} = \frac{\Delta\text{K.E.}}{\text{K.E.}} \times 100 = \frac{1.25\text{K.E.}}{\text{K.E.}} \times 100$$

$$= 125\%$$

@apna_pdf

223. A cricket ball is hit at an angle of 30º to the horizontal with a kinetic energy E. Its kinetic energy when it reaches the highest point is

(a) $\frac{E}{2}$ (b) 0

(c) $\frac{2E}{3}$ (d) $\frac{3E}{4}$

(e) E

TS EAMCET - 09.09.2020 Shift-I
Kerala CEE - 2015
COMEDK-2011

Ans. (d) : Given, θ = 30°

We know that, kinetic energy (K.E. = E)

$$E = \frac{1}{2}mv^2 \quad \text{….(i)}$$

At the highest point vertical component of velocity is zero.

Hence, $u_y = 0$ and $u_x = v\cos\theta$

Then, kinetic energy at highest point (E_H)

$$E_H = \frac{1}{2}m(v\cos\theta)^2 \quad \text{[From equation (i)]}$$

$$E_H = \frac{1}{2}m\times(v\cos 30°)^2 \quad [\because \theta = 30°]$$

$$E_H = \frac{1}{2}mv^2\times\left(\frac{\sqrt{3}}{2}\right)^2$$

$$E_H = \frac{3E}{4}$$

224. A man who is running has half the kinetic energy of a boy of half his mass. The man speeds up by 1 ms^{-1} and then has the same kinetic energy as the boy. The initial speed of the boy is

(a) $\sqrt{2}+1\ \text{ms}^{-1}$ (b) $2(\sqrt{2}+1)\ \text{ms}^{-1}$

(c) $\sqrt{2}\ \text{ms}^{-1}$ (d) $2\ \text{ms}^{-1}$

AP EAMCET (22.04.2019) Shift-I
AMU-2019
Manipal UGET-2013

Ans. (b) : Given,

	Man	boy
Velocity	v_m	v_b
Mass	m	m/2

$$\text{K.E. of man} = \frac{1}{2}[\text{K.E}]_{boy} \quad \text{(given)}$$

$$\frac{1}{2}mv_m^2 = \frac{1}{2}\left[\frac{1}{2}\times\frac{m}{2}\times v_b^2\right]$$

$$v_m^2 = \frac{v_b^2}{4}$$

$$v_m = \frac{v_b}{2} \quad \text{….(i)}$$

According to condition of question, we get the following equation–

$$\frac{1}{2}m(v_m+1)^2 = \frac{1}{2}\times\frac{m}{2}\times v_b^2$$

$$(v_m+1)^2 = \frac{v_b^2}{2}$$

$$v_m + 1 = \frac{v_b}{\sqrt{2}}$$

Putting the value of v_m from equation (i), we get–

$$\frac{v_b}{2}+1 = \frac{v_b}{\sqrt{2}}$$

$$\frac{v_b}{2} - \frac{v_b}{\sqrt{2}} = -1$$

$$-\left(\frac{v_b}{\sqrt{2}} - \frac{v_b}{2}\right) = -1$$

$$\frac{v_b}{\sqrt{2}} - \frac{v_b}{2} = 1$$

$$\frac{\sqrt{2}v_b - v_b}{2} = 1$$

$$v_b\left(\sqrt{2}-1\right) = 2$$

$$v_b = \frac{2}{\sqrt{2}-1}\times\frac{\sqrt{2}+1}{\sqrt{2}+1}$$

$$v_b = \frac{2\left(\sqrt{2}+1\right)}{\left(\sqrt{2}\right)^2-(1)^2}$$

$$v_b = 2\left(\sqrt{2}+1\right)\text{ms}^{-1}$$

225. A girl in a swing is 2.5 m above ground at the maximum height and at 1.5 m above the ground at the lowest point. Her maximum velocity in the swing is (g = 10 ms^{-2})

(a) $5\sqrt{2}\text{ms}^{-1}$ (b) $2\sqrt{5}\text{ms}^{-1}$

(c) $2\sqrt{3}\text{ms}^{-1}$ (d) $3\sqrt{2}\text{ms}^{-1}$

(e) $4\sqrt{2}\text{ms}^{-1}$

Kerala CEE 2012
UP CPMT-2009
AIPMT-2001

Ans. (b) : Given, maximum height (h_1) = 2.5 m, lowest height (h_2) = 1.5 m

As we know that, the maximum height, velocity (v) is zero.

Then, total energy at maximum height–

$$E_1 = mgh_1$$

And total energy at lowest height–

$$E_2 = mgh_2 + \frac{1}{2}mv_{max}^2$$

According to law of conservation of mechanical energy

$$E_1 = E_2$$

$$mgh_1 = \frac{1}{2}mv_{max}^2 + mgh_2$$

or $$mgh_1 = \frac{1}{2}m(v_{max}^2 + 2gh_2)$$

@apna_pdf

$$2gh_1 = v_{max}^2 + 2gh_2$$

$$v_{max}^2 = 2g\,(h_1 - h_2)$$

$$v_{max} = \sqrt{2\times10(2.5-1.5)}$$

$$v_{max} = 2\sqrt{5}\ \ m/s$$

226. The kinetic energy of a body becomes four times its initial value. The new momentum will be ....:

(a) same as the initial value
(b) twice the initial value
(c) thrice the initial value
(d) four times the initial value
(e) half of its initial value

AP EAMCET(18.09.2020), Shift-II
Kerala CEE 2004, 2005

Ans. (b) : Given, $(K.E.)_2 = 4(K.E.)_1$

We know that, $K.E. = \dfrac{p^2}{2m}$

$m_1 = m_2 = m = \text{constant}$

Then, $\dfrac{p_1^{\,2}}{(K.E.)_1} = \dfrac{p_2^{\,2}}{(K.E.)_2}$

$$\frac{p_1^{\,2}}{p_2^{\,2}} = \frac{2m_1(K.E.)_1}{2m_2(K.E.)_2}$$

$$\frac{p_1^{\,2}}{p_2^{\,2}} = \frac{(K.E.)_1}{(K.E.)_2}$$

$$\frac{p_1^{\,2}}{p_2^{\,2}} = \frac{(K.E.)_1}{4(K.E.)_1}$$

$$\frac{p_1^{\,2}}{p_2^{\,2}} = \frac{1}{4} \Rightarrow \frac{p_1}{p_2} = \frac{1}{2}$$

$$p_2 = 2p_1$$

227. If the momentum of a particle is increased by 20%, then is kinetic energy increase by

(a) 44%
(b) 66%
(c) 80%
(d) 30%

MP PMT-2009, 2012
Manipal UGET-2010
WB JEE 2009

Ans. (a) : Let $p_i = p$

$$p_f = p + 20\%\ p$$

$$p_f = 1.2p = \frac{6p}{5}$$

Where, p_i = Initial momentum
p_f = Final momentum

We know that, $K.E. = \dfrac{p^2}{2m}$

Change in kinetic energy,

$$\Delta K.E. = \frac{p_f^{\,2}}{2m} - \frac{p_i^{\,2}}{2m}$$

$$\Delta K.E. = \frac{1}{2m}\left(\frac{6p}{5}\right)^2 - \frac{p^2}{2m}$$

$$\Delta K.E.\ \frac{p^2}{2m}\left(\frac{36}{25}-1\right)$$

$$\Delta K.E. = \frac{11p^2}{50m}$$

Percentage increase in kinetic energy

$$= \frac{\Delta K.E.}{K.E.}\times 100 = \frac{\dfrac{11p^2}{50m}}{\dfrac{p^2}{2m}}\times 100$$

$$= \frac{11p^2}{50m}\times\frac{2m}{p^2}\times 100$$

$$= \frac{11}{25}\times 100 = 44\%$$

228. From a building two balls A and B are thrown such that A is thrown upwards and B downwards (both vertically). If v_A and v_B are their respective velocities on reaching the ground, then:

(a) $v_A > v_B$
(b) $v_A = v_B$
(c) $v_A < v_B$
(d) their velocities depend on their masses.

AMU-2015
AIIMS-2012
AIEEE-2002

Ans. (b) : Given, two balls A and B are thrown such that A is thrown upwards and B downwards (both vertically).

From law of conservation of energy,

Potential energy at height (h) = Kinetic energy at ground

Since, $mgh = \dfrac{1}{2}mv^2$

$$gh = \frac{1}{2}v^2$$

$$v^2 = 2gh$$

$$v = \sqrt{2gh}$$

$\therefore$ $v \propto \sqrt{h}$

Then, $v_A \propto \sqrt{h}$

And, $v_B \propto \sqrt{h}$

Therefore, $v_A = v_B$

229. A mass of 400 g and a mass of 100 g have same KE, then the ratio of their momentums will be

(a) 2 : 1
(b) 1 : 2
(c) 1 : 3
(d) 3 : 1

JEE Main 26.07.2022 Shift-II
UPSEE - 2010
DCE-2007

Ans. (a) : Given, m_1 = 400 gm, m_2 = 100 gm, $E = (KE)_1 = (KE)_2$

We know that,

Kinetic energy $(E) = \dfrac{p^2}{2m}$

@apna_pdf

$$p^2 = 2mE$$

$$p = \sqrt{2mE}$$

$$p_1 = \sqrt{2m_1E} \quad \text{.... (i)}$$

Similarly, $p_2 = \sqrt{2m_2E}$ .... (ii)

Then, $\dfrac{p_1}{p_2} = \dfrac{\sqrt{2m_1E}}{\sqrt{2m_2E}} = \sqrt{\dfrac{m_1}{m_2}}$

$$\frac{p_1}{p_2} = \sqrt{\frac{400}{100}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$$

$$p_1 : p_2 = 2 : 1$$

230. Two bodies A and B having masses in the ratio of 3:1 possess the same kinetic energy. The ratio of linear momentum of B to A is

(a) 1:3 (b) 3:1

(c) $1:\sqrt{3}$ (d) $\sqrt{3}:1$

VITEEE-2017

UP CPMT-2001, 2003, 2007

Ans. (c) : Given

Ratio of mass of to bodies m_A and m_B = 3 : 1

Let,

Momentum of (A) = p_A

Momentum of (B) = p_B

We know that, relation between kinetic energy and momentum.

$$p = \sqrt{2mE}$$

$$p_A = \sqrt{2m_A(KE)_A} \quad \text{....(i)}$$

$$p_B = \sqrt{2m_B(KE)_B} \quad \text{....(ii)}$$

Divide equation (ii) by equation (i), we get-

$$\frac{p_B}{p_A} = \frac{\sqrt{m_B}}{\sqrt{m_A}}$$

[$m_A : m_B$ = 3 : 1 and $(KE)_A = (KE)_B$]

$$\frac{p_B}{p_A} = \sqrt{\frac{1}{3}} = \frac{1}{\sqrt{3}}$$

So, ratio of linear momentum of B to A is

$$p_B : p_A = 1:\sqrt{3}$$

231. The kinetic energy of a body becomes four times its initial value. The new linear momentum will be:

(a) eight times of the initial value

(b) four times of the initial value

(c) twice of the initial value

(d) remain as the initial value

HP CET - 2018

AIIMS-2002, 1998

AIPMT - 2002

Ans. (c) : Given that,

Kinetic energy of a body becomes four times its initial value.

Let, initial kinetic energy = K.E.

∴ Final kinetic energy = 4 K.E.

We know that,

$$\text{K.E.} = \frac{p_1^2}{2m} \quad \text{....(i)}$$

and $$4\text{ K.E.} = \frac{p_2^2}{2m} \quad \text{....(ii)}$$

Dividing equation (i) by equation (ii), we get–

$$\frac{\text{K.E.}}{4\text{K.E.}} = \frac{\dfrac{p_1^2}{2m}}{\dfrac{p_2^2}{2m}}$$

$$\frac{\text{K.E.}}{4\text{K.E.}} = \frac{p_1^2}{p_2^2}$$

$$p_2^2 = 4p_1^2$$

$$p_2 = \sqrt{4p_1^2}$$

$$p_2 = 2p_1$$

So, the new linear momentum will be twice of the initial value.

232. If the linear momentum is increased by 50%, the kinetic energy will increase by:

(a) 50% (b) 100%

(c) 125% (d) 10%

AIIMS-2013, 2014, 2016

Assam CEE-2017

Ans. (c) : Given, linear momentum increased = 50%.

We know that,

Initial kinetic energy $(\text{K.E.})_i = \dfrac{p_i^2}{2m}$

Final kinetic energy $(\text{K.E.})_f = \dfrac{(1.5p_i)^2}{2m}$

or $(\text{K.E.})_f = \dfrac{2.25P_i^2}{2m} = 2.25(\text{K.E.})_i$

Increase kinetic energy $= \dfrac{(\text{K.E.})_f - (\text{K.E.})_i}{(\text{K.E.})_i} \times 100$

$$= \frac{2.25\,(\text{K.E.})_i - (\text{K.E.})_i}{(\text{K.E.})_i} \times 100$$

= 125%

Hence, change in K.E. = 125% of initial

233. A bullet of mass 20 g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision?

(a) 200 m/s (b) 150 m/s

(c) 400 m/s (d) 300 m/s

AIIMS-27.05.2018(M)

JIPMER-2011

Ans. (a) : Given,

Mass of bullet $(m_1) = 20\text{g} = 20 \times 10^{-3}$ kg

Velocity of bullet before collision (v_1) = 600 m/sec

Mass of block (m_2) = 4kg

h = 0.2 m

@apna_pdf

According to law of conservation of linear momentum,

$$m_1v_1 = m_1v + m_2v_2$$

v = velocity of bullet after collision

v_2 = velocity of block

$(20 \times 10^{-3}) \times 600 = (20 \times 10^{-3})v + 4v_2$ .....(i)

After collision, block rises to height 0.2m

From the law of conservation of energy,

$$m_2gh = \frac{1}{2}m_2v_2^2$$

$$2gh = v_2^2$$

$$v_2 = \sqrt{2gh}$$

$$v_2 = \sqrt{2\times10\times0.2} \qquad [\because h = 0.2\text{m}]$$

$$v_2 = \sqrt{4}$$

$$v_2 = 2\text{m/s}$$

Put the value v_2 in equation (i),

$$(20 \times 10^{-3}) \times 600 = (20 \times 10^{-3})\, v + (4 \times 2)$$

$$2 \times 6 = (2 \times 10^{-2})\, v + 8$$

$$(2 \times 10^{-2})\, v = 12 - 8$$

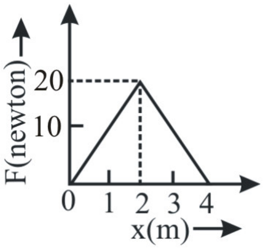
$$(2 \times 10^{-2})\, v = 4$$

$$v = \frac{4}{(2\times10^{-2})}$$

$$v = 2 \times 10^2$$

$$v = 200 \text{ m/sec}$$

234. The graph between the resistive force F acting on a body and the distance covered by the body is shown in the figure. The mass of the body is 25 kg and initial velocity is 2 m/s. When the distance covered by the body is 4 m, its kinetic energy would be



(a) 10 J (b) 20 J

(c) 40 J (d) 50 J

AP EAMCET-03.09.2021 Shift-I
JCECE-2012

Ans. (a) : Given,

Mass of the body (m) = 25 kg

Velocity (v) = 2 m/s

Initial kinetic energy $(K.E.)_1 = \frac{1}{2}mv^2$

$$(K.E.)_1 = \frac{1}{2} \times 25 \times 2 \times 2$$

$$(K.E.)_1 = 50 \text{ J}$$

When the distance covered by the body is 4 m, its kinetic energy will be reduced due to resistive force because body will work against this resistive force.

Therefore,

Work done against resistive force

= Area under F – x graph = Area of triangle

$$= \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 4 \times 20 = 40 \text{ J}$$

Final kinetic energy

= initial kinetic energy – work done against resistive force

= 50 – 40 = 10 J

235. If potential energy is given by $U = \frac{a}{r^2} - \frac{b}{r}$. Then find out maximum force. (Given a = 2, b = 4)

(a) $-\frac{16}{27}$N (b) $-\frac{32}{27}$N

(c) $+\frac{32}{27}$N (d) $+\frac{16}{27}$N

TS EAMCET-04.08.2021 Shift-I
AIIMS-25.05.2019(M) Shift-1

Ans. (a) : Given,

The potential energy,

$$U = \frac{a}{r^2} - \frac{b}{r}$$

And, a = 2 , b = 4

We know that,

Force on the system will be given by

$$F = -\frac{dU}{dr}$$

$$F = -\frac{d}{dr}\left[\frac{a}{r^2} - \frac{b}{r}\right]$$

$$F = -\frac{d}{dr}\left[ar^{-2} - br^{-1}\right]$$

$$F = -a\frac{d}{dr}r^{-2} + b\frac{d}{dr}r^{-1}$$

$$F = 2ar^{-3} - br^{-2}$$

$$F = \frac{2a}{r^3} - \frac{b}{r^2} \qquad \text{....(i)}$$

Force will be maximum if, $\frac{dF}{dr} = 0$

$$\frac{dF}{dr} = 0$$

$$\Rightarrow \frac{d}{dr}\left[\frac{2a}{r^3} - \frac{b}{r^2}\right] = 0$$

$$\Rightarrow 2a\frac{d}{dr}r^{-3} - b\frac{d}{dr}r^{-2} = 0$$

$$\Rightarrow -6ar^{-4} + 2br^{-3} = 0$$

$$\Rightarrow -\frac{6a}{r^4} + \frac{2b}{r^3} = 0$$

$$\Rightarrow b - \frac{3a}{r} = 0$$

$$\Rightarrow \frac{3a}{r} = b$$

@apna_pdf

$\Rightarrow \quad r = 3\left(\frac{a}{b}\right)$

Put the value (a = 2) and (b = 4) in above equation

$\Rightarrow r = 3\left(\frac{2}{4}\right)$

$\Rightarrow r = \frac{3}{2}$

Taking equation (i)

$$F_{max} = \frac{2a}{r^3} - \frac{b}{r^2}$$

Put the value a ,b and r in above equation.

$$F_{max} = \frac{2\times2}{\left(\frac{3}{2}\right)^3} - \frac{4}{\left(\frac{3}{2}\right)^2}$$

$$F_{max} = \frac{4}{\frac{27}{8}} - \frac{4}{\frac{9}{4}}$$

$$F_{max} = \frac{4\times8}{27} - \frac{4\times4}{9}$$

$$F_{max} = \frac{16}{9}\left(\frac{2}{3} - 1\right)$$

$$F_{max} = -\frac{16}{9\times3}$$

$$F_{max} = -\frac{16}{27}\text{N}$$

236. A ball of mass 2 kg is thrown from a tall building with velocity,

$v = (20\,m/s)\hat{i} + (24\,m/s)\hat{j}$ at time t = 0 s.

Change in the potential energy of the ball after, t = 8 s is (The ball is assumed to be in air during its motion between 0 s and 8 s, $\hat{i}$ is along the horizontal and $\hat{j}$ is along the vertical direction. (Take g = 10 m/s^2)

(a) –2.56 kJ (b) 0.52 kJ

(c) 1.76 kJ (d) –2.44 kJ

TS-EAMCET-10.09.2020, Shift-2

TS-EAMCET-03.05.2019, Shift-1

Ans. (a) : Given that,

Initial velocity of ball (u) = $(20\hat{i} + 24\hat{j})$ m/s at time t = 0 sec

Mass (m) = 2 kg

Let v = velocity at time t = 8 sec

Then after time t = 8 sec

Let the equation of motion be,

$$v = u - gt$$

$$v = (20\hat{i} + 24\hat{j}) - (10\hat{j})\times8$$

($\because$ g always work in vertical direction)

$$v = (20\hat{i} - 56\hat{j})\text{ m/s}$$

From the law of conservation of energy,

Change in potential energy = Change in kinetic energy

$$\Delta P.E. = \Delta K.E.$$

$$\Delta P.E. = \frac{1}{2}mu^2 - \frac{1}{2}mv^2$$

$$\Delta P.E. = \frac{1}{2}m[u.u - v.v] = \frac{1}{2}\times2[u.u - v.v]$$

$$\Delta P.E. = \left[(20\hat{i}+24\hat{j}).(20\hat{i}+24\hat{j})\right] - \left[(20\hat{i}-56\hat{j}).(20\hat{i}-56\hat{j})\right]$$

$$\Delta P.E. = [(20)^2 + (24)^2] - [(20)^2 + (56)^2]$$

$$\Delta P.E. = 576 - 3136$$

$$\Delta P.E. = -2560\text{ J} = -2.56\text{ kJ}$$

237. If the kinetic energy of a body becomes four times then its momentum will be

(a) $p_{new} = 3p_{initial}$ (b) $p_{new} = 4p_{initial}$

(c) $p_{new} = 2p_{initial}$ (d) $p_{new} = p_{initial}$

JIPMER-2018

J&K CET- 2004

Ans. (c) : We know, relation between momentum and kinetic Energy (K.E.) = $\frac{p^2}{2m}$

$$p^2 = 2m(K.E.) \quad \text{....(i)}$$

According to the question, kinetic energy becomes four time of its initial value

So, $p_1 = \sqrt{2m(4K.E)}$ .....(ii)

From equation (i) and (ii)

$$\frac{p}{p_1} = \frac{\sqrt{2m(K.E.)}}{\sqrt{2m(4K.E.)}}$$

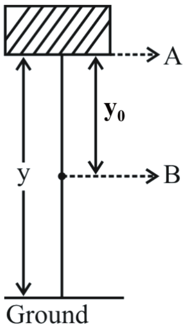
$$\frac{p}{p_1} = \frac{1}{2}\times\frac{\sqrt{2m(K.E.)}}{\sqrt{2m(K.E.)}}$$

$$\frac{p}{p_1} = \frac{1}{2}$$

$$p_1 = 2p$$

Hence, $p_{new} = 2 \times p_{initial}$

238. In the given figure, the block of mass m is dropped from the point 'A'. the expression for kinetic energy of block when it reaches point 'B' is



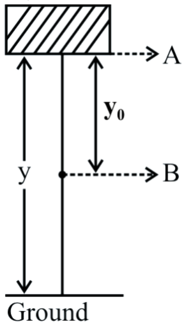
(a) $\frac{1}{2}mgy_0^2$ (b) $\frac{1}{2}mgy^2$

(c) $mg(y-y_0)$ (d) mgy_0

JEE Main-29.06.2022, Shift-II

@apna_pdf

Ans. (d) : Given, $(KE)_A = 0$



Increase in (KE) = Decrease is PE

$(KE)_B - (KE)_A = mgy_0$

$(KE)_B = mgy_0$

239. Water falls from a 40 m high dam at the rate of 9×10^4 kg per hour. Fifty percent of gravitational potential energy can be converted into electrical energy. Using this hydroelectric energy number of 100 W lamps, that can be lit, is:
(Take $g = 10\ ms^{-2}$)

(a) 25 (b) 50
(c) 100 (d) 18

JEE Main-28.06.2022, Shift-II

Ans. (b) : Given,

Height (h) = 40 m

Mass flow rate ($\dot{m}$) = 9×10^4 kg/hour

$$\dot{m} = \frac{9\times10^4}{3600}\ \text{kg/s} = 25\ \text{kg/s}$$

Power (P) = 100 W

We know,

Potential Energy Power = (P.E.) = $\dot{m}gh$

= 25 × 10 × 40

= 10000 J/s

We also know that the half potential energy is converted into electricity.

Electrical Energy power = 50% of gravitational P.E.

Electrical energy (E.E.) $= \frac{1}{2} \times$ P.E.

100 × n = 0.5 × 10000

n = 5000/ 100

n = 50

240. Position of a 3 kg mass moving along the x-axis is given by x = 0.3 cos (ωt) m. If K (t) denotes the kinetic energy at time t,

Then the value of $\dfrac{K\left(\dfrac{\pi}{6\omega}\right)}{K\left(\dfrac{\pi}{3\omega}\right)}$ is

(a) $\frac{1}{3}$ (b) $\frac{1}{2}$

(c) $\frac{\sqrt{3}}{2}$ (d) $\sqrt{3}$

AP EAMCET-07.07.2022, Shift-I

Ans. (a) : Given that,

m = 3kg, x = [0.3 cos(ωt)]m

$$\because \quad v = \frac{dx}{dt} = \frac{d}{dt}[0.3\cos(\omega t)]$$

$$v = 0.3\ \omega \sin(\omega t)$$

$$K(t) = K(t) = \frac{1}{2}mv^2 = \frac{1}{2}m[0.3\omega\sin(\omega t)]^2$$

So from question,

t = π/6ω and π/3ω

$$\therefore \quad \frac{K\left(\frac{\pi}{6\omega}\right)}{K\left(\frac{\pi}{3\omega}\right)} = \frac{\frac{1}{2}m\left[0.3\omega\sin\left(\omega.\frac{\pi}{6\omega}\right)\right]^2}{\frac{1}{2}m\left[0.3\omega\sin\left(\omega.\frac{\pi}{3\omega}\right)\right]^2}$$

$$= \frac{\left[\sin\left(\frac{\pi}{6}\right)\right]^2}{\left[\sin\left(\frac{\pi}{3}\right)\right]^2}$$

$$= \frac{\sin^2 30^\circ}{\sin^2 60^\circ} = \frac{\left(\frac{1}{2}\right)^2}{\left(\frac{\sqrt{3}}{2}\right)^2} = \frac{1/4}{3/4}$$

$$\frac{K\left(\frac{\pi}{6\omega}\right)}{K\left(\frac{\pi}{3\omega}\right)} = \frac{1}{3}$$

241. A body of mass 0.6 kg is moving along a circular path of radius 1 m. If the body moves with $\frac{900}{\pi}$ revolutions per minute, its kinetic energy is

(a) 120 J (b) 270 J
(c) 360 J (d) 240 J

AP EAMCET-06.07.2022, Shift-I

Ans. (b) : Given,

Mass of body (m) = 0.6 kg,

Radius of circular path (r) = 1m,

$$\text{Speed of the body, } n = \frac{900}{\pi}\text{rpm}$$

$$= \frac{900}{60\times\pi} = \frac{15}{\pi}\text{rps}$$

$$\text{Angular speed}(\omega) = 2\pi n = 2\pi\times\frac{15}{\pi} = 30\text{rads}^{-1}$$

$$\text{Linear speed } (v) = \omega r = (30)\ (1) = 30\text{m/s}$$

$$\text{Kinetic Energy } (K) = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\times0.6\times30\times30 = 0.3\times900 = 270.0\text{J}$$

@apna_pdf

242. Position of a 2kg mass moving along the x-axis is given by x = 2 cos [(2s^{-1})t]m. Then maximum kinetic energy of the mass in joule is–

(a) 4 (b) 8

(c) 12 (d) 16

AP EAMCET-08.07.2022, Shift-II

Ans. (d) : Given, m = 2 kg and x = [2 cos(2s^{-1})t]m

We know,

$$v = \frac{dx}{dt}$$

$$v = \frac{d[2\cos(2\,t)]}{dt}$$

$$v = -2 \times 2 \sin(2\,t).$$

$$v = -4 \sin(2\,t)$$

For v_{max} , sin 2t = 1

$$v_{max} = -4$$

Now,

$$\therefore \quad K.E = \frac{1}{2} mv_{max}^2$$

$$K.E = \frac{1}{2} \times 2 \times (-4)^2$$

$$K.E_{max} = 16\text{ J}$$

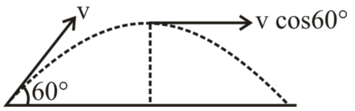
243. A ball is projected with kinetic energy E, at an angle of 60° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become:

(a) Zero (b) $\frac{E}{2}$

(c) $\frac{E}{4}$ (d) E

JEE Main-29.07.2022, Shift-I

Ans. (c) :



$$\because \quad \text{Kinetic energy (K.E.)} = \frac{1}{2} mv^2 = E \text{ (let)}$$

So, the kinetic energy at the highest point is,

$$(K.E.)_h = \frac{1}{2} m\,[v \cos 60°]^2$$

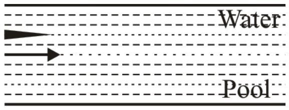
$$(K.E.)_h = \frac{1}{2} mv^2\,[\cos 60°]^2$$

$$(K.E.)_h = E\left[\frac{1}{2}\right]^2$$

$$(K.E.)_h = E. \frac{1}{4}$$

$$(K.E.)_h = \frac{E}{4}$$

244. A bullet of mass 200 g having initial kinetic energy 90 J is shot inside a log swimming pool as shown in the figure. If it's kinetic energy reduces to 40 J within 1s, the minimum length of the pool, the bullet has to travel so that is completely comes to rest is



(a) 45 m (b) 90 m

(c) 125 m (d) 25 m

JEE Main-28.07.2022, Shift-II

Ans. (a) : Given that,

Mass (m) = 200g = 0.2 kg, time (t) = 1 sec.

Initial kinetic energy = 90 J

Initial kinetic energy = $\frac{1}{2} mu^2$

$$90 = \frac{1}{2} mu^2$$

$$\frac{1}{2} \times 0.2 \times u^2 = 90$$

$$0.\,1 \times u^2 = 90$$

$$u^2 = 900$$

$$u = 30\text{ m/s}$$

If it's kinetic energy reduce to 40 J with in 1 second,

Then, $\frac{1}{2} mv^2 = 40$

$$v^2 = \frac{40 \times 2}{0.2}$$

$$v^2 = \frac{800}{2}$$

$$v^2 = 400$$

$$v = 20\text{ m/s}$$

Now, using first law of motion –

$$v = u + at$$

$$20 = 30 + a \times 1$$

$$a = -10\text{ m/s}^2$$

When the bullet completely comes to rest, then we find length of pool by applying third law of motion –

$$v^2 = u^2 + 2as$$

$$0 - u^2 = 2as$$

$$s = \frac{u^2}{-2a}$$

$$= \frac{30 \times 30}{-2 \times -10}$$

$$s = 45\text{ m}$$

245. Potential energy as a function of r is given by $U = \frac{A}{r^{10}} - \frac{B}{r^5}$, where r is the interatomic distance, A and B are positive constants. The equilibrium distance between the two atoms will be:

(a) $\left(\frac{A}{B}\right)^{\frac{1}{5}}$ (b) $\left(\frac{B}{A}\right)^{\frac{1}{5}}$

(c) $\left(\frac{2A}{B}\right)^{\frac{1}{5}}$ (d) $\left(\frac{B}{2A}\right)^{\frac{1}{5}}$

JEE Main-24.06.2022, Shift-II

@apna_pdf

Ans. (c) : Given that,

$$U = \frac{A}{r^{10}} - \frac{B}{r^5}$$

We know that,

$$F = \frac{-dU}{dr}$$

$$F = \frac{-10A}{r^{11}} + \frac{5B}{r^6}$$

For equilibrium, F = 0

$$\frac{-10A}{r^{11}} + \frac{5B}{r^6} = 0$$

$$\frac{10A}{r^{11}} = \frac{5B}{r^6}$$

$$\frac{10A}{5B} = r^5$$

$$\frac{2A}{B} = r^5$$

$$r = \left(\frac{2A}{B}\right)^{\frac{1}{5}}$$

246. A bag of sand of mass 9.8 kg is suspended by a rope. A bullet of 200 g travelling with speed 10 ms^{-1} gets embedded in it, then loss of kinetic energy will be

(a) 4.9 J (b) 9.8 J

(c) 14.7 J (d) 19. 6J

JEE Main-25.07.2022, Shift-II

Ans. (b) : Given that,

$m_1 = 200$ g $= 0.2$ kg $m_2 = 9.8$ kg

$v_1 = 10$ m/s $v_2 = ?$

Initial momentum will be equal to final momentum in this case.

$$p_i = p_f$$

$$m_1v_1 = m_2v_2$$

$$0.2 \times 10 = 9.8 \times v_2$$

$$v_2 = 0.2 \text{ m/s}$$

$$\text{Now, Loss in K.E.} = \frac{1}{2}\times m_1v_1^2 - \frac{1}{2}m_2v_2^2$$

$$= \frac{1}{2}\times(0.2)\times 10^2 - \frac{1}{2}\times 9.8\times(0.2)^2$$

$$= \frac{1}{2}\times(0.2)100 - (0.196)$$

$$= 10.0 - 0.196$$

$$= 9.8 \text{ J}$$

247. The potential energy of an object is U(x) = (5x^2 – 4x^3) J, where x is the position in meter. The position at which the force becomes zero is

(a) $\frac{1}{2}$ m (b) $\frac{5}{6}$ m

(c) $\frac{1}{3}$ m (d) $\frac{2}{3}$ m

TS EAMCET 18.07.2022, Shift-I

Ans. (b) : Given,

$$U(x) = (5x^2 - 4x^3)\text{J}$$

Then, $\frac{dU}{dx} = 0$ (for equilibrium condition)

$$\frac{dU}{dx} = 10x - 12x^2 = 0$$

$$12x^2 - 10x = 0$$

$$x(12x - 10) = 0$$

Either $x = 0$ or $12x - 10 = 0$

But $x \neq 0$

$\therefore$ $12x - 10 = 0$

$$x = \frac{5}{6}\text{m}$$

So, force becomes zero at x = $\frac{5}{6}$m

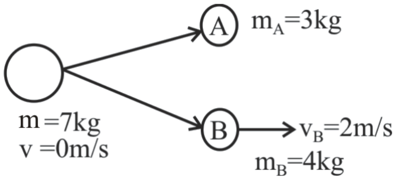
248. An object of mass 7kg initially at rest explodes into two pieces A and B. The mass of A is 3kg. and the mass of B is 4kg. After explosion, B moves with the velocity of 2m/s. The ratio of kinetic energy of A to kinetic energy of B is

(a) $\frac{2}{3}$ (b) $\frac{4}{3}$

(c) $\frac{3}{2}$ (d) $\frac{27}{64}$

TS EAMCET 31.07.2022, Shift-II

Ans. (b) :



According to conservation of momentum,

$$mv = m_Av_A + m_Bv_B$$

$$0 = 3v_A + 4\times 2$$

$$v_A = -8/3 \text{ m/sec.}$$

Taking ratios of kinetic energy of A to B, we get–

$$\frac{(K.E)_A}{(K.E)_B} = \frac{1/2m_Av_A^2}{1/2m_Bv_B^2} = \frac{3\times(-8/3)^2}{4\times(2)^2}$$

$$\frac{(K.E)_A}{(K.E)_B} = \frac{4}{3}$$

249. A particle is released from height S from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively

(a) $\frac{S}{4}, \frac{3gS}{2}$ (b) $\frac{S}{4}, \frac{\sqrt{3gS}}{2}$

(c) $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$ (d) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$

NEET- 2021

@apna_pdf

Ans. (d) : Given that-

Maximum height = S

Let at height h, velocity is v and at this point given, kinetic energy is three times its potential energy.

K.E. = 3 P.E.

$$\frac{1}{2}mv^2 = 3mgh \quad .....(i)$$

$$v^2 = 6gh$$

$$v = \sqrt{6gh} \quad .....(ii)$$

From energy conservation -

$$mgS = K.E. + P.E.$$

$$mgS = \frac{1}{2}mv^2 + mgh$$

From equation (i)

$$mgS = 3mgh + mgh$$

$$S = 4h$$

$$h = \frac{S}{4}$$

Putting the value of h in equation (ii) we get-

$$v = \sqrt{\frac{6g \times S}{4}}$$

$$v = \sqrt{\frac{3gS}{2}}$$

Hence, the height and speed of particle are $\frac{S}{4}$ and $\sqrt{\frac{3gS}{2}}$ respectively.

250. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of the input energy. How much power is generated by the turbine? ($g = 10\ m/s^2$)

(a) 10.2 kW (b) 8.1 kW
(c) 12.3 kW (d) 7.0 kW

NEET- 2021

Ans. (b) : Given that,

Height of water fall (h) = 60m

Rate = 15 kg/s $\quad g = 10\ m/s^2$

$$\frac{m}{t} = 15\ kg/s$$

We know that,

Power, $P = gh\frac{m}{t} \times \frac{90}{100}$

$$P = 10 \times 60 \times 15 \times \frac{90}{100}$$

$$P = 6 \times 15 \times 90$$

$$P = 8100\ W$$

$$P = 8.1 kW \qquad [\because 1000\ W = 1\ kW]$$

251. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 kmph. The centripetal force acting on the car is _______

(a) 250 N (b) 500 N
(c) 750 N (d) 1000 N

AP EAMCET-05.10.2021, Shift-I

Ans. (d) : Given,

Mass (m) = 500 kg

Velocity of the car (v) = 36 km/hr $= 36 \times \frac{5}{18}$ = 10 m/sec

Radius of the circular path (R) = 50 m

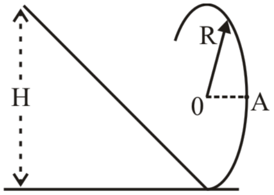
$$F = \frac{mv^2}{R}$$

$$F = \frac{500 \times (10)^2}{50}$$

$$F = 10 \times 100$$

$$F = 1000N$$

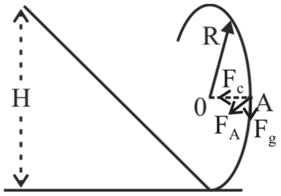
252. A small body slides down a smooth uneven surface from a height H which eventually emerges into a circular loop of radius R(<H). What should be the value of H so that the force on the body at A is $\sqrt{2}$ times its weight?



(a) $H = \frac{3R}{2}$ (b) H = 5R
(c) $H = \frac{5R}{2}$ (d) H = 3R

AP EAMCET-23.08.2021, Shift-I

Ans. (a) :



Given,

Force at A,

$$F_A = \sqrt{2}(mg)$$

Resultant force at point A,

$$F_A = \sqrt{F_g^2 + F_C^2}$$

Where F_g = weight

F_c = Centrifugal force

So, $\sqrt{2}\,mg = \sqrt{(mg)^2 + F_c^2}$

$$2(mg)^2 = (mg)^2 + F_c^2$$

$$(mg)^2 = F_c^2$$

$$F_c = mg$$

We know that,

$$F_c = \frac{mv^2}{R}$$

$$mg = \frac{mv^2}{R}$$

$$v^2 = gR$$

@apna_pdf

From energy conservation,

$$mgH = \frac{mv^2}{2} + mgR$$

$$= \frac{m}{2} \times gR + mgR$$

$$mgH = \frac{3mgR}{2}$$

$$2mgH = 3mgR$$

$$\boxed{H = \frac{3}{2}R}$$

253. When a force $\vec{F}$ acts on a body and the body moves with a velocity $\vec{v}$, the power is given by ______

(a) $\vec{F}.\vec{v}$
(b) $\frac{\vec{F}}{\vec{v}}$
(c) $\frac{\vec{F}}{v^2}$
(d) $\vec{F} \times v^2$

AP EAMCET-05.10.2021, Shift-I

Ans. (a) : Force act on body = $\vec{F}$

Velocity of body = $\vec{v}$

Let displacement of body = $\vec{s}$

Then, work done W = $\overrightarrow{F.s.}$

$$W = Fs\cos\theta$$

We know that, rate of doing work is called power

$$P = \frac{dW}{dt} = (F\cos\theta)\frac{ds}{dt}$$

$$P = F\cos\theta\, v \qquad \left(\because \frac{ds}{dt} = v\right)$$

So,

$$P = \vec{F}.\vec{v}$$

254. What is the nature of the graph between momentum of a body and its kinetic energy?

(a) Straight line
(b) Parabola
(c) Circle
(d) Ellipse

AP EAMCET-25.08.2021, Shift-I

Ans. (b) : We know,

Momentum is the product of mass and velocity,

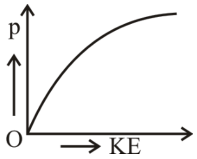
So, Momentum (p) = mv

And Kinetic energy,

$$KE = \frac{1}{2}mv^2$$

Now,

$$KE = \frac{p^2}{2m}$$



So, the graph between p and KE will be parabola and, if KE is along X-axis then parabola should be concave facing towards positive X-axis.

255. When the mass and speed of the body are doubled, the kinetic energy of the body:

(a) Becomes double
(b) Becomes four times
(c) Becomes eight time
(d) Remains unchanged.

AP EAMCET-24.08.2021, Shift-I

Ans. (c) : Given,

$m_1 = 2m$ and $v_1 = 2v$

We know,

$$\text{Kinetic energy } (KE) = \frac{1}{2}mv^2$$

Now,

$$\text{New Kinetic energy } (KE_1) = \frac{1}{2}m_1v_1^2$$

$$KE_1 = \frac{1}{2} \times 2m \times (2v)^2$$

$$KE_1 = \frac{1}{2} \times 8mv^2 = 8 \times \frac{1}{2}mv^2$$

$KE_1 = 8$ KE

The K.E of the body becomes 8 times.

256. A stationary object breaks into two pieces A and B of masses 6 kg and 8 kg respectively. If the velocity of B is 6 ms^{-1}, then find the kinetic energy of A.

(a) 48 J
(b) 192 J
(c) 24 J
(d) 288 J

AP EAMCET-06.09.2021, Shift-I

Ans. (b) : Given,

$m_A = 6$ kg

$m_B = 8$ kg

$v_B = 6$m/sec

By the law of conservation of momentum,

$m_A v_A = m_B v_B$

$6 \times v_A = 8 \times 6$

$v_A = 8$m/sec

Kinetic energy of body A

$$(K.E)_A = \frac{1}{2}m_A v_A^{\ 2}$$

$$= \frac{1}{2} \times 6 \times (8)^2 = \frac{1}{2} \times 6 \times 64$$

$KE_A = 192$ J

The Kinetic Energy of body A is 192 J.

257. Two bodies having kinetic energy in the ratio 4 : 1 are moving with same linear velocity. The ratio of their masses is______

(a) 1 : 2
(b) 1 : 1
(c) 4 : 1
(d) 1 : 4

AP EAMCET-20.08.2021, Shift-II

Ans. (c) : Given,

$$\frac{K.E_1}{K.E_2} = \frac{4}{1}$$

We know,

$$KE = \frac{1}{2}mv^2$$

$$K \cdot E \propto mv^2$$

@apna_pdf

$$\frac{K.E_1}{K.E_2}=\frac{m_1v_1^2}{m_2v_2^2}$$

Given, same linear velocity –

$$v_1 = v_2$$

$$\frac{4}{1}=\frac{m_1}{m_2}$$

The ratio $m_1 : m_2 = 4:1$

258. What is the shape of the graph between speed and kinetic energy of a body?

(a) A straight line (b) A hyperbola

(c) A parabola (d) Exponential

AP EAMCET-19.08.2021, Shift-II

Ans. (c) : Let X-axis denotes velocity v and Y-axis denotes kinetic energy K.E.

$$\text{Kinetic energy}\,(KE)=\frac{1}{2}mv^2$$

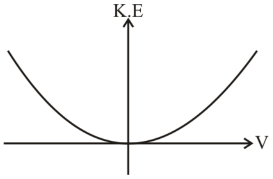
$$KE \propto v^2$$

$$K.E = cv^2 \qquad \text{.......(i)}$$

Where $c=\frac{1}{2}m$ is constant

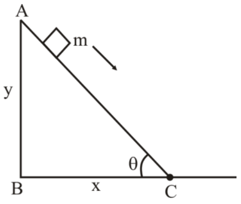
Convert equation (i) in X-Y form,

$$Y = c\,X^2$$



So, the graph between speed and kinetic energy of body is parabolic in shape.

259. A particle slides down along an inclined plane AC. If the plane is frictionless, kinetic energy of particle at 'C' is



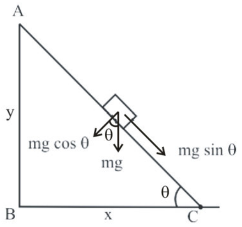
(a) mgy (b) mgx

(c) $mg\left(\frac{y}{\sin\theta}\right)$ (d) $mg\left(\frac{y}{\cos\theta}\right)$

AP EAMCET-25.08.2021, Shift-I

Ans. (a) : From triangle ΔABC,

$$\sin\theta=\frac{y}{AC}$$



Accelerate along AC,

$v^2 = u^2 + 2as$ [From equation of motion]

$$v^2 = u^2 + 2a\,(AC)$$

$\because$ $mg\sin\theta = ma$

$$a = g\sin\theta$$

$$v^2 - 0 = 2\times(g\sin\theta)\,(AC)$$

$$v^2 = 2g\left(\frac{y}{AC}\right)(AC)$$

$$v^2 = 2g.y$$

$$\text{Kinetic energy }(K.E.)=\frac{1}{2}mv^2$$

$$=\frac{1}{2}\times m\times(2gy)$$

$$\boxed{K.E. = mgy}$$

260. When a ball of mass 50g is thrown upwards. it raises to a maximum height of 100 m. At what height its K.E. will be reduced to 70%

(a) 30 m (b) 40 m

(c) 60 m (d) 70 m

AP EAMCET-03.09.2021, Shift-II

Ans. (a) : Given,

Mass (m) = 50g = 0.05 kg

Height (h) = 100 m

At maximum height

$$v^2 = u^2 - 2gh$$

$$0 = u^2 - 2(10)(100)$$

$$u=\sqrt{2000}=20\sqrt{5}$$

$$KE=\frac{1}{2}mu^2=\frac{1}{2}(0.05)\left(20\sqrt{5}\right)^2$$

$$=\frac{1}{2}\times(0.05)(2000)=50J$$

Now,

$$K.E' = 70\%\ K.E$$

$$K.E' = 0.7KE = 0.7\times 50$$

$$= 35J$$

Then,

$$K.E'=\frac{1}{2}mv^2$$

$$v=\sqrt{\frac{35\times 2}{0.05}}=\sqrt{1400}$$

Using the equation of motion,

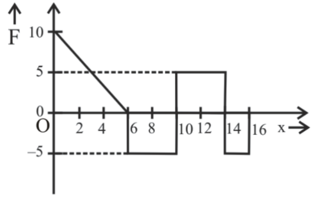
$$v^2 = u^2 - 2gh$$

$$1400 = 2000 - 2(10)h$$

$$-600 = -20h$$

$$h = 30\ m$$

261. As shown in the figure below, the force F on a particle varies with position in a certain manner. The kinetic energy of the particle at x = 0 is 12J. What is its kinetic energy at x = 14?

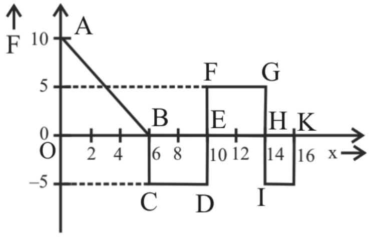


@apna_pdf

(a) 42 J (b) 70 J
(c) 40J (d) 0J

Assam CEE-2021

Ans. (a): Given, Kinetic energy $(K.E.)_{(x=0)} = 12$ J



Work done (W) = Area under (F–x) graph

Work done (W) = Area of ΔAOB + Area of ⊔ BCDE+ Area of ⊔ EFGH

$$W = \frac{1}{2}\times 6\times 10+\left(-5\right)\times\left(10-6\right)+5\times\left(14-10\right)$$

W = 30 – 20 + 20

W = 30 J

We know that,

Work done (W) = Change in kinetic energy

Work done = $(K.E.)_f - (K.E.)_i$

30 J = $(K.E.)_f$ – 12 J

So,

$(K.E.)_f = 42$ J

262. A particle is moving along the x-axis and has potential energy U = 1 + 12x + 6x^2. If the particle is now released at x = –5, the maximum value of x can be

(a) –1 (b) 0
(c) 1 (d) 3

Assam CEE-2021

Ans. (d) : Given that,

Potential energy (U) $= 1+12x+6x^2$

$$\because F = \frac{-dU}{dx}$$

$$= \frac{-d(1+12x+6x^2)}{dx}$$

F = 0 –12 –12x

At equilibrium position –

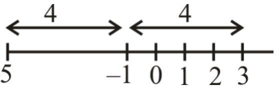
F = 0

–12 – 12 x = 0

x = –1

It will oscillate about x = –1 with amplitude of 4m

∴ Maximum value of x will be 3 m



263. A machine gun fires 360 bullets per minute. Each bullet travels with velocity of 500 m/s. If the power of the machine gun is 4.5 kW then the mass of each bullet is

(a) 2 g (b) 5 g
(c) 6 g (d) 10 g

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (c) : Given,

No. of bullets (n) = 360,

Velocity of each bullet (v) = 500 m/s

Power (P) = 4500 watt, t = 1 minute = 60 s

We know,

$$\text{Kinetic energy of 360 bullets (K.E)} = n\times\frac{1}{2}mv^2$$

$$= 360\times\frac{1}{2}\times m\times(500)^2$$

$$K.E = \left(45\times 10^6\, m\right) J$$

$$\text{Power (P)} = \frac{K.E}{\text{Time}}$$

$$4500 = \frac{45\times 10^6\times m}{60}$$

$$m = \frac{4500\times 60}{45\times 10^6}$$

$$m = 0.006\,kg$$

$$m = 6\,g$$

264. A ball of mass 2 kg is moving in xy plane with a potential energy given as $U=\left(12x+16y\right)J$, x and y being in meter. Assume the initial position of the ball at t = 0 is at origin (0,0) and it is moving with a velocity of $\left(15\hat{i}+20\hat{j}\right)$m/s. Then identify the correct statement.

(a) The path of the ball is parabolic
(b) The direction of motion of the ball initially at t = 0 parallel to the direction of acceleration
(c) The speed of the ball at t = 2s is 5 m/s
(d) The magnitude of acceleration of the ball is 8 m/s^2

TS EAMCET 06.08.2021, Shift-II

Ans. (c) : Given,

$U = \left(12x+16y\right)J$, m = 2kg

We know,

$$F_x = -\frac{dU}{dx} = -12N$$

$$F_y = -\frac{dU}{dy} = -16N$$

Then,

$F_x = ma_x$

$-12 = 2a_x$

$a_x = -6$ m/s^2

Similarly,

$a_y = -8$ m/s^2

Now, velocity at t = 2s will be –

$$\vec{v} = \vec{u}+\vec{a}t$$

$$\vec{v} = \left(15\hat{i}+20\hat{j}\right)+\left(-6\hat{i}-8\hat{j}\right)2$$

$$\vec{v} = 3\hat{i}+4\hat{j}$$

$$|\vec{v}| = \sqrt{3^2+4^2} = \sqrt{25}$$

$$|\vec{v}| = 5\,m/s$$

@apna_pdf

Magnitude of $|\vec{a}| = \sqrt{a_x^2 + a_y^2}$

$$= \sqrt{6^2 + 8^2}$$

$$= \sqrt{36 + 64}$$

$$|\vec{a}| = 10 m/s^2$$

265. Consider a rocket is being fired. The kinetic energy of the rocket is increased by 16 times where as its total mass is reduced by half through the burning of fuel. The factor by which its momentum increases is

(a) 8 (b) $2\sqrt{2}$
(c) 4 (d) $4\sqrt{2}$

TS EAMCET 04.08.2021, Shift-I

Ans. (b) : Given,

$$m_2 = \frac{m_1}{2}, \quad (K.E)_2 = 16(K.E)_1$$

We know,

Kinetic energy (K.E) $= \frac{p^2}{2m}$

Therefore,

The ratio of $\frac{(K.E.)_2}{(K.E.)_1} = \frac{p_2^2/2m_2}{p_1^2/2m_1} = \frac{2p_2^2}{p_1^2}$

$$\frac{16(K.E.)_1}{(K.E.)_1} = \frac{2p_2^2}{p_1^2}$$

$$p_2^2 = 8p_1^2$$

$$p_2 = 2\sqrt{2}\,p_1$$

266. The momentum of a particle is numerically equal to its kinetic energy. What will be the velocity of the particle?

(a) $1m.s^{-1}$ (b) $2m.s^{-1}$
(c) $3m.s^{-1}$ (d) $4m.s^{-1}$

AP EAMCET-06.09.2021, Shift-II

Ans. (b) : We know that,
Momentum (p) = mv

Kinetic energy (K.E.) $= \frac{1}{2}mv^2$

According to question
Momentum of particle (p) = Kinetic energy of particle

$$mv = \frac{1}{2}mv^2$$

$$v^2 - 2v = 0$$

Or $v(v - 2) = 0$

Hence, the velocity of particle is 2 m/sec.

267. A running boy has the same kinetic energy as that of a man of twice his mass. If the speed of the boy is 14.14 ms^{-1}, the speed of the man is

(a) $1.414\ ms^{-1}$ (b) $0.25\ ms^{-1}$
(c) $10\ ms^{-1}$ (d) $3\sqrt{2}\ ms^{-1}$
(e) $0.5\ ms^{-1}$

Kerala CEE 2020

Ans. (c) : Given, speed of boy (v) = 14.14 m/s
According to question,

$$\frac{1}{2}mv^2 = \frac{1}{2}2mv'^2$$

$$v'^2 = \frac{v^2}{2}$$

$$v' = \frac{v}{\sqrt{2}} = \frac{14.14}{1.414}$$

$$v' = 10\ m/s$$

268. A body of mass 2 kg is moving with a momentum of 10 kg ms^{-1}. The force needed to increase its kinetic energy by four times in 10 seconds is

(a) 2 N (b) 4 N
(c) 1 N (d) 0.5 N
(e) 8 N

Kerala CEE 2020

Ans. (c) : Given, momentum initial (p_i) = 10 kg m/s, Mass (m) = 2 kg

$$\because \quad u_1 = \frac{p_1}{m} = \frac{10}{2} = 5 m/s$$

$$(K.E.)_1 = \frac{1}{2}mu_1^2 = \frac{1}{2} \times 2 \times 5^2 = 25\ J$$

According to the question,

$$(K.E.)_2 = 4 \times (K.E.)_1 = 4 \times 25 = 100\ J$$

So, $\frac{1}{2}mv^2 = 100 J$

$$v^2 = \frac{100 \times 2}{2}$$

$$v = 10\ m/s$$

Now, v = u + at

$$10 = 5 + a \times 10$$

$$a = 0.5\ m/s^2$$

Therefore, Force (F) = ma

$$= 2 \times 0.5 = 1N$$

269. The energy required to accelerate a car from 10 ms^{-1} to 20 ms^{-1} is ____ times the energy required to accelerate the car from rest to 10 ms^{-1}

(a) Equal (b) 4 times
(c) 2 times (d) 3 times

AP EAMCET (Medical)-07.10.2020, Shift-I

Ans. (d) : Given,
Energy required accelerating from 10m/s to 20m/s –

$$E_1 = \frac{1}{2}m(\Delta v)^2 = \frac{1}{2}m(20^2 - 10^2)$$

$$E_1 = \frac{1}{2}m(400 - 100)$$

$$E_1 = \frac{1}{2}m \times 300$$

$$E_1 = 150\ m$$

And energy required accelerating from rest to 10 m/s –

$$E_2 = \frac{1}{2}m(10^2 - 0^2)$$

@apna_pdf

$$E_2 = \frac{1}{2} m \times 100$$

$$E_2 = 50\text{ m}$$

$$\frac{E_1}{E_2} = \frac{150\text{ m}}{50\text{ m}}$$

$$\boxed{E_1 = 3E_2}$$

270. The kinetic energy of an electron which is accelerated through a potential difference of 100 V will be _____

(a) 6.626×10^{-34}J (b) 1.16×10^{-4}J

(c) 418.6 J (d) 1.6×10^{-17}J

AP EAMCET-24.09.2020, Shift-I

Ans. (d) : Given,

Charge of electron (e) = 1.6×10^{-19} C

Potential difference (ΔV) = 100 V

We know,

Energy acquired by electron when it is acceleration through a potential difference (100 V)

So, kinetic energy,

$$KE = E = e \times \Delta V$$
$$= 1.6 \times 10^{-19} \times 100$$
$$= 1.6 \times 10^{-17}\text{ J}$$

271. A tangential force F acts along the rim of a ring of radius R and displaces the ring through an angle θ. The work done by the force is :

(a) $FR^2\theta$ (b) $\frac{FR}{\theta}$

(c) $\frac{FR\theta}{2}$ (d) $FR\theta$

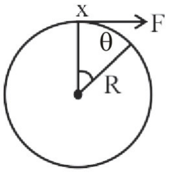
AP EAMCET-24.09.2020, Shift-II

Ans. (d) : Given,

Displacement = θ

Arc length = x

Then, x = Rθ



We know,

Work done = F.x

= F(Rθ)

Hence, work done by the force is FRθ.

272. Which of the following statements is correct?

(A) Kinetic energy of a system can be changed without changing its momentum

(B) Kinetic energy of a system cannot be changed without changing its momentum

(C) Momentum of a system cannot be changed without changing its kinetic energy

(D) Body cannot have energy without having momentum

(a) A (b) B

(c) C (d) D

AP EAMCET-23.09.2020, Shift-II

Ans. (a) : Kinetic energy of a system can be changed without changing its momentum because it is dependent on mass and velocity.

273. Two object of masses m_1 and m_2 posses equal kinetic energies. If p_1 and p_2 are their respective momentum, then $p_1 : p_2$ is

(a) $m_1 : m_2$ (b) $m_2 : m_1$

(c) $\sqrt{m_1} : \sqrt{m_2}$ (d) $m_1^2 : m_2^2$

AP EAMCET-07.10.2020, Shift-I

Ans. (c) : We know,

Kinetic energy $(KE) = \frac{1}{2}mv^2$

$$KE = \frac{1}{2}mv^2 \times \frac{m}{m} = \frac{(mv)^2}{2m}$$

$$KE = \frac{p^2}{2m}$$

For p_1,

$$KE = \frac{p_1^2}{2m_1}$$

$$p_1 = \sqrt{2m_1 KE}$$

For p_2,

$$KE = \frac{p_2^2}{2m_2}$$

$$p_2 = \sqrt{2m_2 KE}$$

$$\frac{p_1}{p_2} = \sqrt{\frac{2m_1 KE}{2m_2 KE}} = \sqrt{\frac{m_1}{m_2}}$$

Thus the momentum ratio,

$$p_1 : p_2 = \sqrt{m_1} : \sqrt{m_2}$$

274. Kinetic energy of a body increases .... times when its momentum is increased 'n' times:

(a) n (b) 2n

(c) $\sqrt{n}$ (d) n^2

AP EAMCET-23.09.2020, Shift-II

Ans. (d) : We know,

Kinetic energy $(KE) = \frac{1}{2}mv^2$

$$KE = \frac{1}{2} \times mv^2 \times \frac{m}{m}$$

$$= \frac{1}{2} \times (mv)^2 \times \frac{1}{m}$$

$$= \frac{p^2}{2m}$$

$$KE \propto p^2$$

So, if the momentum increased by n time

[i.e. $p \to np$]

$$KE \propto (np)^2$$

$$KE \propto n^2p^2$$

Thus, if the momentum of a body is increased by n times, then the kinetic energy also increases by n^2 times.

@apna_pdf

275. A uniform sphere of mass m = 2.5 kg and radius R = 10 cm rotates with an angular velocity ω = 200 rad/s about its diameter. Find its kinetic energy.

(a) 150 J (b) 200 J

(c) 300 J (d) 350 J

TS EAMCET 29.09.2020, Shift-I

Ans. (b) : Given,

Mass of sphere (m) = 2.5 kg

Radius (R) = 10cm = 0.1m

Angular velocity (ω) = 200 rad/s.

For sphere,

$$I = \frac{2}{5}mR^2 \qquad .....(i)$$

Rotational kinetic energy of Sphere (K.E.) $= \frac{1}{2}I\omega^2$

Putting the value of I from equation (i), we get–

$$\text{K.E.} = \frac{1}{2}\times\frac{2}{5}mR^2\omega^2$$

$$= \frac{1}{5}\times mR^2.\omega^2$$

$$= \frac{1}{5}\times 2.5\times 0.1\times 0.1\times 200\times 200$$

$$= \frac{25\times 40}{5}$$

Kinetic energy (K.E.) = 200 J

276. A block of mass 'm' moving on a frictionless horizontal surface collides with a spring of spring constant 'K' and compresses it through a distance 'x'. The maximum momentum of the block after collision is

(a) $\sqrt{mK}\,x$ (b) mx^2/K

(c) Zero (d) $Kx^2/2m$

MHT-CET 2020

Ans. (a) : Momentum would be maximum when kinetic energy would be maximum. Total elastic potential energy of spring converted to kinetic energy.

According to conservation of energy.

$$PE_{spring} = KE_{mass}$$

$$\frac{1}{2}Kx^2 = \frac{p^2}{2m}$$

$$mKx^2 = p^2$$

$$p = \sqrt{mKx^2}$$

$$p = \sqrt{mK}.x$$

277. The kinetic energy of a light body and a heavy body is same. Which one of the following statements is CORRECT?

(a) Body having high velocity has greater momentum

(b) The heavy body has greater momentum

(c) Both bodies have same momentum

(d) The light body has greater momentum

MHT-CET 2020

Ans. (b) : We know that,

$$\text{Kinetic energy (K.E.)} = \frac{1}{2}mv^2$$

Or $\quad \text{K.E.} = \frac{p^2}{2m}$

$$p^2 = 2m\,(\text{K.E.})$$

$$p = \sqrt{2m(\text{K.E.})}$$

∵ Momentum depends on mass

$$p \propto \sqrt{m}$$

Kinetic energy for both bodies will be same but heavy body will have more momentum.

278. The kinetic energy acquired by a body of mass 'M' in travelling a certain distance 'd', starting from rest, under the action of constant force is

(a) Inversely proportional to $\sqrt{M}$

(b) Directly proportional to M

(c) Independent of M

(d) Directly proportional to $\sqrt{M}$

MHT-CET 2019, 2020

Ans. (c) : Given , mass of body = M, distance = d

We know that, F = Ma

Or $\quad a = \frac{F}{M} \qquad ....(i)$

From third equation of motion,

∵ $\quad v^2 = u^2 + 2ad$

So, $\quad v^2 = 2ad$ (at rest, u = 0) $\qquad .....(ii)$

Kinetic energy (K.E.) $= \frac{1}{2}Mv^2$

Putting the value of 'v^2' from equation (ii)-

$$\text{K.E.} = \frac{1}{2}M\times 2ad$$

$$\text{K.E.} = M.a.d$$

Put the value of a from equation (i)-

$$\text{K.E.} = M\times\frac{F}{M}\times d$$

$$\text{K.E.} = F\times d$$

Here, force is constant so K.E. is directly proportional to displacement.

Hence, kinetic energy is independent of the mass M.

279. A particle at rest explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2 respectively. The ratio of kinetic energies E_1 to E_2 respectively is

(a) $m_2 : m_1$ (b) $m_1 : m_2$

(c) $1 : m_2$ (d) 1 : 1

MHT-CET 2020

Ans. (a) : Given,

Mass of two particles are m_1 and m_2

Velocity of two particles are v_1 and v_2

According to conservation of linear momentum,

$$m_1 v_1 = m_2 v_2$$

$$\frac{m_1}{m_2} = \frac{v_2}{v_1} \qquad ....(i)$$

@apna_pdf

Kinetic energy $(E_1) = \frac{1}{2}m_1v_1^2$

And kinetic energy $(E_2) = \frac{1}{2}m_2v_2^2$

Ratio between E_1 and E_2 are

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}m_1v_1^2}{\frac{1}{2}m_2v_2^2}$$

$$= \frac{m_1}{m_2} \times \left(\frac{v_1}{v_2}\right)^2$$

$$= \frac{m_1}{m_2} \times \left(\frac{m_2}{m_1}\right)^2 \text{ [From eq (i)]}$$

$$\frac{E_1}{E_2} = \frac{m_2}{m_1} \Rightarrow E_1 : E_2 = m_2 : m_1$$

280. A body initially at rest is acted upon by a constant force (F) for time (t). The kinetic energy at time t is

(a) $\frac{F^2t^2}{2m}$ (b) $\frac{Ft}{2m}$

(c) $\frac{F^2t^2}{m}$ (d) $\left(\frac{Ft}{m}\right)^2$

MHT-CET 2020

Ans. (a) : Given, force = F, time = t

We know that, F = ma

$$a = \frac{F}{m}$$

Now, from first law of motion

$v = u + at$

So, $v = at$ (at rest, u = 0) ....(i)

Put the value of 'a' in equation (i) –

$$v = \frac{Ft}{m} \quad ....(ii)$$

Kinetic energy $= \frac{1}{2}mv^2$

Putting the value of 'v' from equation (ii) –

$$\text{K.E.} = \frac{1}{2}m\left(\frac{Ft}{m}\right)^2$$

$$\text{K.E.} = \frac{1}{2}m \times \frac{F^2t^2}{m^2}$$

$$\text{K.E.} = \frac{F^2t^2}{2m}$$

281. A solid sphere of mass 'M' and radius 'R' is rotating about its diameter. A disc of same mass and radius is also rotating about an axis passing through its centre and perpendicular to the plane but angular speed is twice that of the sphere. The ratio of kinetic energy of disc to that of sphere is

(a) 4 : 1 (b) 6 : 1

(c) 3 : 1 (d) 5 : 1

MHT-CET 2020

Ans. (d) : Let, I_s and I_d are the moment of Inertial of sphere and disc respectively and ω_s and ω_d are angular speed of sphere and disc respectively.

Given, $\omega_d = 2\omega_s$

Kinetic energy of sphere $(K_s) = \frac{1}{2}I_s\omega_s^2$

Kinetic energy of disc $(K_d) = \frac{1}{2}I_d\omega_d^2$

Ratio between disc's kinetic energy and spheres kinetic energy

$$\frac{K_d}{K_s} = \frac{I_d\omega_d^2}{I_s\omega_s^2} = \frac{\frac{1}{2}MR^2(2\omega_s)^2}{\frac{2}{5}MR^2\omega_s^2}$$

$$= = \frac{\frac{1}{2}MR^2 4\omega_s^2}{\frac{2}{5}MR^2\omega_s^2}$$

$$= \frac{\frac{4}{2}}{\frac{2}{5}}$$

$$= \frac{5}{1} = 5:1$$

Thus, $K_d : K_s$ is 5 : 1

282. A solid sphere of mass 1 kg and radius 10 cm rolls without slipping on a horizontal surface, with velocity of 10 cm/s. The total kinetic energy of sphere is

(a) 0.007 J (b) 0.05 J

(c) 0.01 J (d) 0.07 J

MHT-CET 2020

Ans. (a) : Given,

Mass (m) = 1 kg

Radius (r) = 10cm = 0.1 m.

Velocity (v) = 10 cm/s = 0.1m/s

The momentum of inertia of solid sphere (I) $= \frac{2}{5}mr^2$

We know that,

$$\omega = \frac{v}{r}$$

Total kinetic energy of a rolling body without slipping (K.E.) = Rotational kinetic energy + linear kinetic energy

$$\text{K.E.} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2} \times \left(\frac{2}{5}mr^2\right) \times \left(\frac{v}{r}\right)^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{5}mr^2 \times \frac{v^2}{r^2} \quad = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$= \frac{7}{10}mv^2 \quad = \frac{7}{10} \times 1 \times (0.1)^2$$

$$= 7 \times 10^{-3} \quad = 0.007\text{J}$$

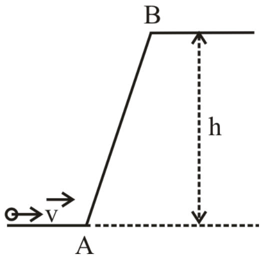
Thus, total kinetic energy is 0.007J.

@apna_pdf

283. A solid sphere is rolling on a frictionless surface with translational velocity 'v'. It climbs that inclined plane from 'A' to 'B' and then moves away from B on the smooth horizontal surface. The value of 'v' should be

(a) $\left[\dfrac{10gh}{7}\right]^{\frac{1}{2}}$ (b) $\sqrt{2gh}$

(c) $\dfrac{10gh}{7}$ (d) $\sqrt{gh}$



MHT-CET 2020

Ans. (a) : We know,

Potential energy = Translational energy + Rotational energy

$$\frac{1}{2}mv^2+\frac{1}{2}I\omega^2=mgh \quad \text{....(i)}$$

Moment of inertia of solid sphere –

$$I=\frac{2}{5}mr^2$$

And $\omega=\dfrac{v}{r}$

Putting the value of I and ω in equation (i)–

$$\therefore\ \frac{1}{2}mv^2+\frac{1}{2}\left(\frac{2}{5}mr^2\right)\times\frac{v^2}{r^2}=mgh$$

$$\frac{1}{2}mv^2+\frac{1}{5}mv^2=mgh$$

$$\frac{7}{10}mv^2=mgh$$

$$v^2\left(\frac{7}{10}\right)=gh$$

$$v^2=\frac{10}{7}gh$$

$$v=\sqrt{\frac{10}{7}gh}=\left[\frac{10gh}{7}\right]^{1/2}$$

Hence,

To climb the inclined surface velocity should be greater than, $\sqrt{\dfrac{10}{7}gh}$.

284. A machine which is 70% efficient raised a 10 kg body through a certain distance and spends 100 J energy. The body is then released. On reaching the ground, the kinetic energy of the body will be

(a) 0 (b) 70 J

(c) 50 J (d) 35 J

AP EAMCET (18.09.2020) Shift-II

Ans. (b) : Given, mass (m) = 10 kg

Efficiency of machine = 70%

Actual work done by machine,

$W = 70\% \times 100$

$W = 70$ Joule

Now, $W = mgh$

$70 = 10 \times 10 \times h \qquad [\because g = 10\ m/s^2]$

$\dfrac{70}{100}=h$

$h = 0.70$ m

Then, applying conservation of energy–

K.E = P.E

K.E = P.E = mgh

$= 10 \times 10 \times 0.70$

K.E = 70 Joule

285. A particle is moving on X-axis has potential energy $U = 2 - 20x + 5x^2$J along X-axis. The particle is released at x = – 3. The maximum value of x will be (x is in metre and U is in Joules)

(a) 5 m (b) 3 m

(c) 7 m (d) 8 m

AP EAMCET (18.09.2020) Shift-I

Ans. (c) : Given that, $U = 2 - 20x + 5x^2$ J

We know that, Force (F) $=-\dfrac{dU}{dx}$

$F = -[-20 + 10x]$

$F = 20 - 10x \quad$ ....(i)

If particle is in equilibrium position then F = 0

Putting the value of F in equation (i), we get–

$0 = 20 - 10x$

$20 = 10x$

$x = 2$ m

The particle is released from x = –3. So, amplitude from x = –3 and x = 2 is 5 m.

The maximum value of x will be–

$x = 5 + 2$

$x = 7$ m

286. A particle moves in a straight line with its retardation proportional to its displacement. The loss of its kinetic energy for any displacement x is proportional to

(a) $\dfrac{1}{x}$ (b) x

(c) x^2 (d) e^x

UPSEE 2019

Ans. (c): Given that, particles move in a straight line with its retardation proportional to its displacement.

$a \propto x$

$a = -kx$

Where, k = proportionality constant

$vdv = kx\,dx$

Integrating both side, we get–

$$\int_{v_i}^{v_f} vdv=-\int_0^x kx\,dx$$

Where v_i and v_f are initial and final velocity of particle respectively.

@apna_pdf

$$\left(\frac{v^2}{2}\right)_{v_i}^{v_f} = -k\left(\frac{x^2}{2}\right)_0^X$$

$$\frac{v_f^2}{2} - \frac{v_i^2}{2} = -k\frac{x^2}{2}$$

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -\frac{mkx^2}{2}$$

$$(K.E.)_{final} - (K.E.)_{initial} = -\frac{1}{2}mkx^2$$

Hence, loss in kinetic energy $\propto x^2$

287. An object, moving with velocity 5 m/s, undergoes an acceleration of 1 m/s^2 at time t = 0. If the object has a mass of 1 kg, the kinetic energy (KE) of the object at time t = 5 s is

(a) KE = 12.5 joules (b) KE = 20 joules
(c) KE = 30 joules (d) KE = 50 joules
(e) KE = 0 joules

Kerala CEE-2019

Ans. (d): Given,
Initial velocity (u) = 5 m/s
Acceleration (a) = 1 m/s^2
Mass (m) = 1kg
Time (t) = 5 sec
From 1st equation of motion,

$$v = u + at$$

At t = 5 sec,

$$v = 5 + 1 \times 5$$
$$v = 10 \text{ m/s}$$

Kinetic energy of the object $(K.E.) = \frac{1}{2}mv^2$

$$= \frac{1}{2} \times 1 \times (10)^2$$

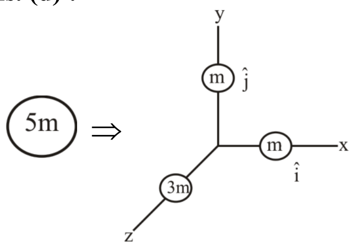
$$KE = 50 \text{ joules}$$

288. A particle of mass 5 m at rest suddenly breaks on its own into three fragments. Two fragments of mass m each move along mutually perpendicular direction with each speed v. The energy released during the process is

(a) $\frac{3}{5}mv^2$ (b) $\frac{5}{3}mv^2$
(c) $\frac{3}{2}mv^2$ (d) $\frac{4}{3}mv^2$

NEET (Odisha) - 2019

Ans. (d) :



Linear momentum is conserved -

$$P_i = P_f$$

$$0 = mv\hat{i} + mv\hat{j} + 3m\vec{v}'$$

$$\vec{v}' = \frac{-v\hat{i} - v\hat{j}}{3}$$

$$|\vec{v}'| = \frac{1}{3}\sqrt{v^2 + v^2}$$

$$|\vec{v}'| = \frac{\sqrt{2}}{3}v$$

Hence,

$$(K.E.)_f = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(3m)\frac{2}{9}v^2 = \frac{4mv^2}{3}$$

So, the energy released -

$$K.E. = (K.E.)_f - (K.E.)_i \quad \because KE_i = 0$$

$$= \frac{4mv^2}{3} - 0 \quad [\because (KE)_i = 0]$$

$$K.E. = \frac{4mv^2}{3}$$

289. One object of mass 20 kg is moving with speed 10 m/s in west direction another object of mass 10 kg is moving with 15 m/s in North direction. Both collide and stick together. Choose the correct alternative

(a) There K.E. is conserved as it is inelastic collision
(b) There K.E. is conserved as it is elastic collision
(c) There momentum is conserved as it is inelastic collision
(d) There momentum is conserved as it is elastic collision

JIPMER-2019

Ans. (c) : There momentum is conserved as it is in elastic collision. When object of mass 20 kg is moving with speed 10 ms^{-1} in west direction collide with object of mass 10 kg is moving with 15 m/s in North direction. Both collide and stick together. Hence, it is perfectly inelastic collision.

290. The rate of decrease of kinetic energy is 9.6 J/s. Find the magnitude of force acting on particle when it's speed is 3 m/s.

(a) 3.2 N (b) 4.8 N
(c) 2.4 N (d) 5.6 N

JIPMER-2019

Ans. (a) : Rate of decrease of kinetic energy $\left(\frac{dK}{dt}\right) = 9.6 \text{ J/sec}$, speed (v) = 3 m/s

We know that, kinetic energy $(K.E.) = \frac{1}{2}mv^2$

Rate of change of K.E. is

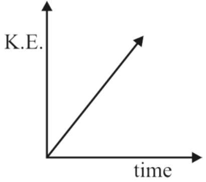
$$\frac{dK}{dt} = \frac{1}{2}m \times 2v \times \frac{dv}{dt} = v \times \frac{mdv}{dt}$$

$$\frac{dK}{dt} = v \times \text{Force}$$

$$\text{Force} = \left(\frac{dK}{dt}\right) \times \frac{1}{v} = \frac{9.6}{3} = 3.2 \text{ N}$$

@apna_pdf

291. A body moves along a straight line and the variation of its kinetic energy with time is linear as shown in the figure below. Then the force acting on the body is



(a) Zero
(b) Constant greater than zero
(c) Inversely proportional to velocity
(d) Directly proportional to velocity

MHT-CET 2019

Ans. (c) : As we know that,

$$\text{K.E.} \propto t$$

$$\frac{1}{2}mv^2 \propto t$$

$$\frac{1}{2}mv^2 = Ct$$

Differentiating w.r.t. time, we get,

$$\frac{m}{2}.2v\frac{dv}{dt} = C$$

$$m\frac{dv}{dt} = \frac{C}{v} \qquad \text{....(i)}$$

$$F = \frac{C}{v} \qquad \left(\because F = m\frac{dv}{dt}\right)$$

$$F \propto \frac{1}{v}$$

So, force acting on body will be inversely proportional to velocity.

292. A particle of mass 10 g is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them to take the particle far away from the sphere (you make take $G = 6.67 \times 10^{-11}$ Nm^2/kg^2)

(a) 3.33×10^{-10} J
(b) 13.34×10^{-10} J
(c) 6.67×10^{-10} J
(d) 6.67×10^{-9} J

AIIMS-26.05.2019(M) Shift-1

Ans. (c) : Given,

Mass of particle (m_1) = 10g

$$m_1 = 10 \times 10^{-3} \text{ kg}$$

$$m_1 = 10^{-2} \text{ kg}$$

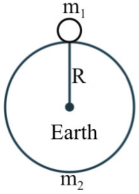
Mass of sphere (m_2) = 100 kg = 10^2 kg

Radius of sphere (R) = 10 cm

$$R = 10 \times 10^{-2} \text{ m}$$

$$R = 10^{-1} \text{ m}$$

Gravitational constant (G) = 6.67×10^{-11} N-m^2/kg^2



Work done (w) = difference in potential energy

$$W = \Delta u$$

$$W = u_f - u_i$$

Where,

u_f = Final potential energy
u_i = Initial potential energy

$\because$ $u_f = 0$

Then, $W = u_i$

$$W = \left[\frac{Gm_1m_2}{R}\right]$$

$$W = \frac{Gm_1m_2}{R}$$

$$W = \frac{6.67 \times 10^{-11} \times 10^{-2} \times 10^2}{0.1}$$

$$W = \frac{6.67 \times 10^{-11}}{0.1}$$

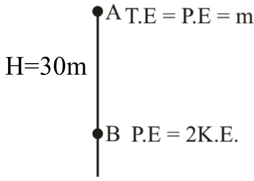
$$W = 6.67 \times 10^{-10} \text{ J}$$

293. A body is released from a height of 30 m vertically downwards. The speed of the body at which potential energy is twice that of kinetic energy is
(Acceleration due to gravity, $g = 10$ ms^{-2})

(a) $20\sqrt{2}$ ms^{-1}
(b) $10\sqrt{2}$ ms^{-1}
(c) 10 ms^{-1}
(d) 20 ms^{-1}

AP EAMCET (21.04.2019) Shift-II

Ans. (b) : Given, Potential energy = 2(Kinetic energy)



We know that,

Total energy = Potential energy + Kinetic energy

$$mgH = \text{P.E.} + \text{K.E.}$$

$$mgH = 2\text{K.E.} + \text{K.E.}$$

$$mgH = 3\text{K.E.}$$

$$mg \times 30 = 3\text{K.E.}$$

$$mg \times 10 = \text{K.E.}$$

$$mg \times 10 = \frac{1}{2}mv^2$$

$$10 \times 10 \times 2 = v^2$$

$$v = \sqrt{200}$$

$$v = 10\sqrt{2} \text{ ms}^{-1}$$

294. Potential energy of a body of mass 1 kg free to move along x-axis is given by $U(x) = \left(\frac{x^2}{2} - x\right)$ J. If the total mechanical energy of the body is 2 J, then the maximum speed of the body is (Assume only conservative force acts on the body)

(a) $\sqrt{5}$ ms^{-1}
(b) 5 ms^{-1}
(c) 3.5 ms^{-1}
(d) $\sqrt{8}$ ms^{-1}

AP EAMCET (21.04.2019) Shift-I

@apna_pdf

Ans. (a) : Given that,

Mass (m) = 1 kg, $U(x)=\left(\frac{x^2}{2}-x\right)$

Total energy = 2 J, v_{max} = ?

For maximum speed,

$$U(x)=\left(\frac{x^2}{2}-x\right) \quad ....(i)$$

Differentiate equation (i) w.r.t. x, we get–

$$\frac{dU}{dx}=0$$

$$\frac{d}{dx}\left(\frac{x^2}{2}-x\right)=0$$

$$x-1=0$$

$$x=1$$

Putting the value of x in equation (i), we get

$$U=-\frac{1}{2}\,J$$

Total energy (E) = Potential energy (U) + Kinetic energy (K)

$$2=-\frac{1}{2}+\frac{1}{2}mv^2$$

$$2+\frac{1}{2}=\frac{1}{2}v^2 \quad (\because m=1kg)$$

$$v_{max}=\sqrt{5}\ ms^{-1}$$

295. Two particles of masses m_1 and m_2 have equal kinetic energies. The ratio of their momentum is:

(a) $m_1 : m_2$ (b) $m_2 : m_1$

(c) $\sqrt{m_1} : \sqrt{m_2}$ (d) $m_1^2 : m_2^2$

Karnataka CET-2018

Ans. (c): We know that,

Kinetic energies $(KE)=\frac{1}{2}mv^2$

The relation between kinetic energy and momentum–

$$(KE)=\frac{p^2}{2m}$$

Where m = mass of the particle

$$(KE)_1=\frac{p_1^2}{2m_1}$$

and $$(KE)_2=\frac{p_2^2}{2m_2}$$

Given that,

$$(KE)_1=(KE)_2$$

$$\frac{p_1^2}{2m_1}=\frac{p_2^2}{2m_2}$$

p_1, p_2 are moment of two particle, m_1 and m_2 respectively

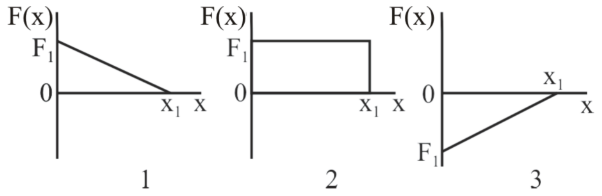
$$\therefore \quad \frac{p_1^2}{p_2^2}=\frac{2m_1}{2m_2}$$

$$\left(\frac{p_1}{p_2}\right)^2=\left(\frac{m_1}{m_2}\right)$$

$$\frac{p_1}{p_2}=\frac{m_1}{m_2}$$

$$p_1 : p_2=\sqrt{m_1} : \sqrt{m_2}$$

296. The graphs below show the magnitude of the force on a particle as it moves along the positive x-axis from the origin to $x = x_1$. The force is parallel to the x-axis and is conservative. The maximum magnitude F_1 has the same value for all graphs. Rank the situations according to the change in the potential energy associated with the force, least (or most negative) to greatest (or most positive)



(a) 1, 2, 3

(b) 1, 3, 2

(c) 3, 2, 1

(d) 2, 1, 3

AMU-2018

Ans. (d) : We know that,

Net work = – ΔU

W = – ΔU

For fig (i) $\Delta U_1=-\frac{1}{2}F_1\times x_1$

For fig (ii) $\Delta U_2=-F_1\times x_1$

For fig (iii) $\Delta U_3=+\frac{F_1\times x_1}{2}$

$\Delta U_2<\Delta U_1<\Delta U_3$ = 2, 1, 3.

Hence, option (d) is correct

297. A bullet of mass 50 g is fired from a rifle of mass 2 kg and the total kinetic energy produced by the explosion is 2050 J. Then the kinetic energy of the bullet and the rifle are

(a) 2000 J and 50 J (b) 1500 J and 50 J

(c) 2500 J and 25 J (d) 1000 J and 75 J

Assam CEE-2018

Ans. (a) : Given, m_B = 50g = 0.05 kg

m_R= 2 kg

$$(K.E.)_B=\frac{p_B^2}{2m_B}$$

$$(K.E.)_R=\frac{p_R^2}{2m_R}$$

Energy of explosion E = $(K.E.)_B+(K.E.)_R$

According to conservation of law of momentum

$p_B=p_R=p$ (let)

So, $$2050=\frac{p_B^2}{2(0.05)}+\frac{p_R^2}{2(2)}$$

@apna_pdf

$$2050 = p^2\left[\frac{1}{0.1}+\frac{1}{4}\right]$$

$$2050 = p^2\left[\frac{41}{4}\right]$$

$$p^2 = 200$$

$$\therefore \quad K_B = \frac{p^2}{2m_B} = \frac{200}{2\times 0.05} = 2000\text{J}$$

Therefore, $K_R = (2050 - 2000)$ J = 50 J.

298. A running man has half the kinetic energy of that of a boy of half of his mass. The man speeds up by 1m/s so as to have same K.E. as that of the boy. The original speed of the man will be

(a) $\sqrt{2}$ m/s
(b) $\left(\sqrt{2}-1\right)$ m/s
(c) $\frac{1}{\left(\sqrt{2}-1\right)}$ m/s
(d) $\frac{1}{\sqrt{2}}$ m/s

VITEEE-2018

Ans. (c) : Let,

Mass of man = M kg
Speed of man = v m/s
Mass of boy = $\frac{M}{2}$ kg
Speed of boy = v_1 m/s

Given,

$$(K.E)_{man} = \frac{1}{2}(K.E)_{boy}$$

$$\frac{1}{2}Mv^2 = \frac{1}{2}\left(\frac{1}{2}.\frac{M}{2}v_1^2\right)$$

$$v^2 = \frac{1}{4}v_1^2 \quad \text{....(i)}$$

Man speed up by 1m/s.
New speed = (v + 1) m/s

$$(K.E)_{man} = (K.E)_{boy}$$

$$\frac{1}{2}M(v+1)^2 = \frac{1}{2}\left(\frac{M}{2}\right)v_1^2$$

$$(v+1)^2 = \frac{1}{2}v_1^2 \quad \text{....(ii)}$$

Divide equation (i) by equation (ii), we get-

$$\frac{v^2}{(v+1)^2} = \frac{\frac{1}{4}v_1^2}{\frac{1}{2}v_1^2}$$

$$\frac{v^2}{(v+1)^2} = \frac{1}{2}$$

$$\frac{v}{v+1} = \frac{1}{\sqrt{2}}$$

$$\sqrt{2}v = (v+1)$$

So,

$$v = \frac{1}{\left(\sqrt{2}-1\right)} \text{ m/s}$$

299. A body accelerates uniformly from rest to a velocity of 1 ms^{-1} in 15 second. The kinetic energy of the body will be $\frac{2}{9}$ J when 't' is equal to [Take mass of body as 1 kg]

(a) 4 s
(b) 8 s
(c) 10 s
(d) 12 s

COMEDK 2018

Ans. (c) : Given,

Initial velocity (u) = 0
Final velocity (v) = 1m/s
Time (t) = 15 second
Kinetic energy of the body = $\frac{2}{9}$ J
Mass (m) = 1 kg

We know,

$$\text{Acceleration (a)} = \frac{v-u}{t}$$

$$a = \frac{1-0}{15}$$

$$a = \frac{1}{15} \text{ m/s}^2$$

We know, kinetic energy–

$$K.E. = \frac{1}{2}mv^2$$

$$\frac{2}{9} = \frac{1}{2}\times 1\times v^2$$

$$v^2 = \frac{2}{9}\times 2$$

$$v = \sqrt{\frac{4}{9}}$$

$$v = \frac{2}{3} \text{ m/sec}$$

From 1st equation of motion,

$$v = u + at$$

$$\frac{2}{3} = 0 + \frac{1}{15}t$$

$$\frac{t}{15} = \frac{2}{3}$$

$$t = \frac{2\times 15}{3}$$

t = 10 sec

300. A light and heavy body have equal momentum, which one has greater kinetic energy?

(a) A light body
(b) A heavy body
(c) Both have equal kinetic energies
(d) Data given is incomplete

JCECE-2018

Ans. (a) : As we know that,

$$K = \frac{p^2}{2m} \quad \text{....(i)}$$

@apna_pdf

As given in the question momentum p is same for heavy and light body.

Then, from equation (i)

$$K \propto \frac{1}{m} \qquad \text{(when p is constant).}$$

Thus, heavy body has more mass and hence has lower kinetic energy but light body has less mass and hence has greater kinetic energy.

301. A policeman fires a bullet of mass 50 g with a speed of 200 m/s, in a wooden piece of thickness 2.0 cm. The bullet leaves the wooden piece with only 10% of its initial kinetic energy. By how much percentage has the speed of the bullet been reduced?

(a) 74.2% (b) 40%
(c) 90% (d) 68.4%

CG PET -2018

Ans. (d) : Given that,

Mass of bullet = 50 g

Speed of bullet = 200 m/s

Thickness of wooden piece = 2 cm

Kinetic energy, when bullet leaves the wooden piece,

$$(\text{K.E.})_f = (\text{K.E.})_i \times \frac{10}{100}$$

$$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 \times \frac{10}{100}$$

$$v_f = \frac{v_i}{\sqrt{10}} \qquad \text{....(i)}$$

Hence, reduced speed of bullet–

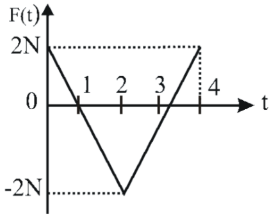
$$= \frac{v_i - v_f}{v_i} \times 100$$

Putting the value of v_f from equation (i), we get–

$$= \frac{v_i - \frac{v_i}{\sqrt{10}}}{v_i} \times 100$$

$$= \frac{v_i\left(1 - \frac{1}{\sqrt{10}}\right)}{v_i} \times 100 = 68.4\%$$

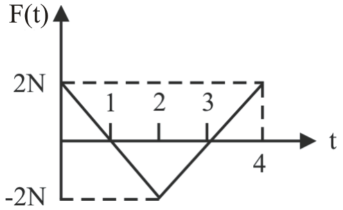
302. A block of mass 1 kg is free to move along the x-axis. It is at rest and from time t=0 onwards it is subjected to a time-dependent force F(t) in the x-direction. The force F(t) varies with t as shown in figure. The kinetic energy of the block at t = 4 s is



(a) 1J (b) 2J
(c) 3J (d) 0J
(e) 4J

Kerala CEE -2018

Ans. (d) :



Then, total momentum of block = Area of given graph

$$p = A_1 + A_2 + A_3$$

$$p = \frac{1}{2}\times 1\times 2 - \frac{1}{2}\times 2\times 2 + \frac{1}{2}\times 1\times 2$$

$$p = 0$$

We know that, p = mv = 0

At, t = 4 sec

$$\text{K.E.} = \frac{1}{2}mv^2 = 0$$

303. The force acting on a particle of mass m moving along the x-axis is given by $F(x) = Ax^2 - Bx$. Which one of the following is the potential energy of the particle?

(a) $2Ax - B$ (b) $-\frac{x^2}{6}(2Ax - 3B)$
(c) $Ax^3 - Bx^2$ (d) Zero

NDA (II) 2017

Ans. (b) Given,

$$F(x) = Ax^2 - Bx$$

We know,

$$F = \frac{-dU}{dx}$$

$$dU = -Fdx$$

Integrating both side,

$$\int dU = -\int Fdx$$

$$U = -\int (Ax^2 - Bx)dx$$

$$U = -\int Ax^2dx - \int -Bx\,dx$$

Now,

$$U = -A\left[\frac{x^3}{3}\right] + B\left[\frac{x^2}{2}\right]$$

$$U = -\frac{Ax^3}{3} + \frac{Bx^2}{2}$$

$$\text{Hence, } U = -\frac{x^2}{6}[2Ax - 3B]$$

304. An athlete throws a shotput of mass 25 kg with an initial speed of 4 ms^{-1} at an angle of 45° with the horizontal from a height of 2 m above the ground. Assuming air resistance to be negligible, the kinetic energy of the shotput when it just touches the ground is ($g = 10\ ms^{-2}$)

(a) 600 J (b) 100 J
(c) 700 J (d) 800 J

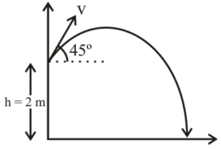
AP EAMCET-25.04.2017, Shift-I

@apna_pdf

Ans. (c) : Mass, (m) = 25 kg

Initial speed, (v) = 4m/s. angle $\theta = 45^o$

Height, (h) = 2m



Initial kinetic energy of the shot put, $\frac{1}{2}mv^2$

$$K.E = \frac{1}{2}\times(25)\times(4)^2 = \frac{1}{2}\times 25\times 16 = 200J$$

And initial potential energy, at height 2m,

$P.E = mgh$

$= 25 \times 10 \times 2 = 500$ J

Total initial energy of the shot put = K.E + P.E

= 200 + 500

= 700 J

By energy conservation

Initial energy = Final energy

At ground h = 0, so potential energy P.E = 0

700 J = K.E + P.E

700 J = K.E + 0

K.E = 700 J

305. Two blocks A & B of mass 2M and M are moving along X- direction on a frictionless plane. Their instantaneous position are given by t and t^2, respectively. At a particular instant of time T, the kinetic energy of both particles are equal. Then,

(a) at T, $V_A > V_B$
(b) at T, $V_B > V_A$
(c) at T, $V_A > V_B$
(d) $V_A > V_B$ always

TS EAMCET(Medical)-2017

Ans. (b) : Suppose that,

Velocities of A and B at the instant T be V_A and V_B respectively

Kinetic energy of A,

$$K_A = \frac{1}{2}(2M)V_A^2$$

Kinetic energy of B,

$$K_B = \frac{1}{2}(M)V_B^2$$

But $K_A = K_B$

$$\therefore \quad \frac{1}{2}(2M)V_A^2 = \frac{1}{2}MV_B^2$$

Thus $2V_A^2 = V_B^2$

So, $V_B > V_A$

Instantaneous position are given,

$x_A = t$, $x_B = t^2$

$$\because \quad V_A = \frac{dx_A}{dt} = \frac{d(t)}{dt} = 1$$

$$V_B = \frac{dx_B}{dt} = \frac{d(t^2)}{dt} = 2t$$

$V_A < V_B$ at time T

306. A bullet of mass 50 g is fired from a riffle of mass 2 Kg and the total kinetic energy produced by the explosion is 2050J. The kinetic energy of the bullet is

(a) 50 J
(b) 2000 J
(c) 5020 J
(d) 585.7 J

TS EAMCET(Medical)-2017

Ans. (b): Given,

Mass of the bullet (m) = 50g = 0.05kg

Mass of the riffle (M) = 2 kg

Total kinetic energy (E) = 2050 J

For bullet, For riffle,

$$(K.E)_B = \frac{p_B^2}{2m} \qquad (K.E)_R = \frac{p_R^2}{2M}$$

Energy explosion (E) = $(K.E)_B + (K.E)_R$

$$= \frac{p_B^2}{2m} + \frac{p_R^2}{2M}$$

According to conservation of law of momentum,

Inertia momentum = Final momentum

$0 = p_B + p_R$

$p_B = -p_R$

$p_B = -p_R = p$

$$\text{Then,} \quad E = \frac{p^2}{2m} + \frac{(p)^2}{2M}$$

$$2050 = \frac{p^2}{2\times 0.05} + \frac{p^2}{2\times 2}$$

$$p^2 = 200 \qquad \dots (i)$$

For kinetic energy of bullet,

$$(K.E)_B = \frac{p^2}{2m} = \frac{200}{2\times 0.05} = 2000\,J$$

307. The potential energy of a system increases if work is done

(a) upon the system by a non conservative force
(b) by the system against a conservative force
(c) by the system against a non conservative force
(d) upon the system by a conservative force

VITEEE-2016, 2017

Ans. (b) : When work is done upon a system by a conservative force then its potential energy (du) increases.

We know that,

Conservation force is,

$$F_c = \frac{-dU}{dr}$$

$$-dU = F_c \times dr$$

$$-dU = W_c$$

Where W_c work done by conservative force.

308. The kinetic energy K of a particle moving along a circle of radius R depends on the distance covered s, as K = as^2, where, a is a constant. Then the force acting on the particle is–

(a) $2a\frac{s^2}{R}$
(b) $2as\left(1+\frac{s^2}{R^2}\right)^{1/2}$

@apna_pdf

(c) 2as (d) $2a\frac{R^2}{s}$

BCECE-2017

Ans. (b) : Given,

$K = as^2$ [where, a is a constant]

Let, mass of particle = m and v = velocity of particle

$\therefore$ Kinetic energy, $K.E = \frac{1}{2}mv^2$

Now,

$$as^2 = \frac{1}{2}mv^2$$

$$mv^2 = 2as^2$$

$$v^2 = \frac{2as^2}{m}$$

$$v = s\sqrt{\frac{2a}{m}}$$

Since, $a_R = \frac{v^2}{R}$

$$a_R = \frac{\left(s\sqrt{\frac{2a}{m}}\right)^2}{R}$$

$$a_R = \frac{s^2\frac{2a}{m}}{R}$$

$$a_R = \frac{2as^2}{mR}$$

We know that,

Tangential acceleration –

$$a_t = \frac{dv}{dt}$$

$$a_t = \frac{dv}{ds}\cdot\frac{ds}{dt}$$

$$a_t = \frac{dv}{ds}\cdot v \quad \left[\because v = \frac{ds}{dt}\right]$$

$$a_t = v\cdot\frac{dv}{ds}$$

Put the value $\left(v = s\sqrt{\frac{2a}{m}}\right)$ and taking differentiation w.r.t. s, we get $\left(\frac{dv}{ds} = \sqrt{\frac{2a}{m}}\right)$ in above equation.

Then,

$$a_t = s\sqrt{\frac{2a}{m}}\cdot\sqrt{\frac{2a}{m}}$$

$$a_t = \frac{2as}{m}$$

Now,

$$a' = \sqrt{a_R^2 + a_t^2}$$

$$a' = \sqrt{\left(\frac{2as^2}{mR}\right)^2 + \left(\frac{2as}{m}\right)^2}$$

$$a' = \sqrt{\left(\frac{2as}{m}\right)^2\left[\left(\frac{s}{R}\right)^2 + (1)^2\right]}$$

$$a' = \frac{2as}{m}\sqrt{\frac{s^2}{R^2}+1}$$

$$a' = \frac{2as}{m}\left(1+\frac{s^2}{R^2}\right)^{1/2}$$

So, force acting on particle is

$$F = ma'$$

$$F = 2as\left(1+\frac{s^2}{R^2}\right)^{1/2}$$

309. A small object of mass of 100 gm moves in a circular path. At a given instant velocity of the object is 10 $\hat{i}$ m/s and acceleration is $(20\hat{i}+10\hat{j})$ m/s^2. At this instant of time, rate of change of kinetic energy of the object is

(a) 200 kgm^2/s^3 (b) 300 kgm^2/s^3

(c) 10000 kgm^2/s^3 (d) 20 kgm^2/s^3

UPSEE - 2017

Ans. (d) : Given, m = 100 gm = 100 $\times 10^{-3}$ = 0.1 kg, v = $10\hat{i}\,m/s, a = (20\hat{i}+10\hat{j})\,m/s^2$

We know that,

Rate of change of kinetic energy $\frac{d(K.E)}{dt} = \vec{F}.\vec{v}$

$$= m\vec{a}.\vec{v} \quad (\vec{F} = m\vec{a})$$

$$= (0.1)\times(20\hat{i}+10\hat{j}).10\hat{i}$$

$$= 0.1\times20\hat{i}.10\hat{i} + 0.1\times10\hat{j}.10\hat{i} \quad (\hat{i}.\hat{i} = 1, \hat{i}.\hat{j} = 0)$$

$$= 0.1\times20\times10 + 0 = 20\text{ kg m}^2/\text{s}^3$$

310. The potential energy of a conservative system is given by V(x) = (x^2 – 3x) joule, where x is measured in metre. Then its equilibrium position is at

(a) 1.5 m (b) 2 m

(c) 3 m (d) 1 m

(e) 5 m

Kerala CEE- 2013, 2010

Ans. (a) : Given, $V(x) = (x^2 - 3x)$

We know that, $F = -\frac{dV(x)}{dx}$

$$F = -\frac{d}{dx}(x^2-3x) = -(2x-3) = -2x+3$$

At equilibrium position (F = 0)

$$-2x + 3 = 0$$

$$x = \frac{3}{2} = 1.5\text{m}$$

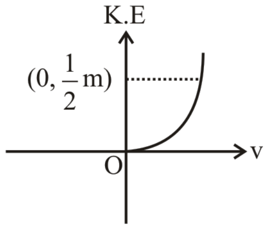
@apna_pdf

311. The shape of the curve representing the relation between the speed and kinetic energy of a moving object is

(a) parabola
(b) ellipse
(c) straight line with positive slope
(d) straight line with negative slope
(e) exponential

BCECE 2014
Kerala CEE 2012

Ans. (a) :



Kinetic energy is given by

$$K.E. = \frac{1}{2}mv^2$$

Where, m is the mass of the object and v is the speed of the object

$$K.E. \propto v^2$$

So, the curve between speed and kinetic energy is parabola.

312. Two bodies A and B have masses 20 kg and 5 kg respectively. Each one is acted upon by a force of 4kg-wt. If they acquire the same kinetic energy in times t_A and t_B, then the ratio $\frac{t_A}{t_B}$ is

(a) $\frac{1}{2}$
(b) 2
(c) $\frac{2}{5}$
(d) $\frac{5}{6}$
(e) $\frac{1}{5}$

Kerala CEE - 2008

Ans. (b) : Given that, m_A = 20 kg, m_B = 5 kg, F = 4 kgwt = 4N

We know that, F = ma

Acceleration, $a_A = \frac{F}{m_A} = \frac{4}{20} = \frac{1}{5}$

$$a_A = \frac{v_A}{t_A} = \frac{1}{5}$$

$$a_B = \frac{F}{m_B} = \frac{4}{5}$$

$$a_A = \frac{1}{5} = \frac{v_A}{t_A} \Rightarrow v_A = \frac{t_A}{5}$$

$$a_B = \frac{4}{5} = \frac{v_B}{t_B} \Rightarrow v_B = \frac{4t_B}{5}$$

If they acquired same kinetic energy–

$$(K.E)_A = (K.E)_B$$

Then, $\frac{1}{2}m_A v_A^2 = \frac{1}{2}m_B v_B^2$

$$20\left(\frac{t_A}{5}\right)^2 = 5\left(\frac{4t_B}{5}\right)^2$$

$$4\left(\frac{t_A}{5}\right)^2 = \left(\frac{4t_B}{5}\right)^2$$

$$\frac{4(t_A^2)}{25} = \frac{16(t_B^2)}{25}$$

$$t_A^2 = 4t_B^2$$

$$\frac{t_A^2}{t_B^2} = \frac{4}{1}$$

$$\frac{t_A}{t_B} = \sqrt{\frac{4}{1}}$$

Then, time ratio

$t_A : t_B = 2 : 1$

313. A running man has the same kinetic energy as that of a boy of half his mass. The man speeds up by 2 ms^{-1} and the boy changes his speed by x ms^{-1}, so that the kinetic energies of the boy and the man are again equal. Then x in ms^{-1} is :

(a) $-2\sqrt{2}$
(b) $+2\sqrt{2}$
(c) $\sqrt{2}$
(d) 2
(e) $1/\sqrt{2}$

Kerala CEE 2006

Ans. (b) : Let, the mass of a man = m

Therefore, mass of the boy = $\frac{m}{2}$

Let, the velocity of man v_1 and velocity of boy v_2.

Then, $\frac{1}{2}mv_1^2 = \frac{1}{2}\left(\frac{m}{2}\right)v_2^2$

$$v_1 = \frac{v_2}{\sqrt{2}}$$

According to question–

$$\frac{1}{2}m(v_1+2)^2 = \frac{1}{2}\left[\frac{m}{2}(v_2+x)^2\right]$$

$$\therefore \quad (v_1+2)^2 = \frac{(v_2+x)^2}{2}$$

$$v_1 + 2 = \frac{v_2+x}{\sqrt{2}}$$

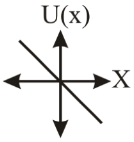
$$\frac{v_2}{\sqrt{2}} + 2 = \frac{v_2}{\sqrt{2}} + \frac{x}{\sqrt{2}} \qquad \left[\because v_1 = \frac{v_2}{\sqrt{2}}\right]$$

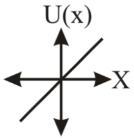
$$\frac{x}{\sqrt{2}} = 2$$

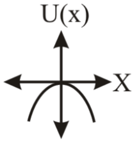
x = $2\sqrt{2}$ m/s

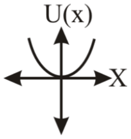
314. A particle is placed at the origin and force F = kx is acting on it (where, k is positive constant). If U (0) = 0 the graph of U(x) versus X will be, (where, U is the potential energy function)

@apna_pdf

(a)


(b)


(c)


(d)


UPSEE - 2015

Ans. (c) : Given, F = k x

Since, Force $(F) = \frac{-dU(x)}{dx} = kx$

$$\int -dU(x) = \int kx\,dx$$

$$-U(x) = k\left(\frac{x^2}{2}\right)$$

$$U(x) = -\left(\frac{1}{2}\right)kx^2$$

$$U(x) = \frac{-kx^2}{2}$$

$$U(x) \propto -x^2$$

This is the equation of parabola symmetric to U-axis in negative direction.

315. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

(a) x^2
(b) e^x
(c) x
(d) $\log_e x$

UPSEE - 2007

Ans. (a) : Given that,

$$a = -kx \quad \text{.....(i)}$$

Where, a = Acceleration
x = displacement
k = proportionality constant

And negative sign is due to retardation.

Now, from equation

$$a = -kx$$

$$\frac{dv}{dt} = -kx \qquad \left[\because a = \frac{dv}{dt}\right]$$

$$\frac{dv}{dx}.\frac{dx}{dt} = -kx$$

$$vdv = -kx.dx$$

Taking integration both side, we get–

$$\int_{v_1}^{v_2} v.dv = \int -kx.dx$$

$$\left[\frac{v^2}{2}\right]_{v_1}^{v_2} = -k.\frac{x^2}{2}$$

Multiplying by m both side, we get–

$$\frac{1}{2}\left(v_2^2 - v_1^2\right)m = -\frac{1}{2}kx^2 \times m$$

Loss in kinetic energy (ΔK.E) = $-\frac{1}{2}mkx^2$

$$(\Delta K.E) \propto x^2$$

316. A steel ball of mass 5g is thrown downward with velocity 10 m/s from height 19.5 m. It penetrates sand by 50 cm. The change in mechanical energy will be: (g = 10 m/s^2)

(a) 1 J
(b) 1.25 J
(c) 1.5 J
(d) 1.75 J

UPSEE - 2006

Ans.(b) : Given, m = 5 g = 0.005 kg, h = 19.5 m, x = 50 cm = 0.5 m, v = 10 m/s, g = 10 m/s^2

The change in mechanical energy

$$\Delta U = mg(h+x) + \frac{1}{2}mv^2$$

$$\Delta U = m\left[g(h+x) + \frac{1}{2}v^2\right]$$

$$\therefore \quad \Delta U = 0.005\left[10\times(19.5+0.5) + \frac{1}{2}\times(10)^2\right]$$

$$\Delta U = 1.25\,J$$

317. The potential energy for a force field $\vec{F}$ is given by U (x, y) = cos (x + y). The force acting on a particle at position given by coordinates (0, π/4) is

(a) $-\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$
(b) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$
(c) $\left(\frac{1}{2}\hat{i}+\frac{\sqrt{3}}{2}\hat{j}\right)$
(d) $\left(\frac{1}{2}\hat{i}-\frac{\sqrt{3}}{2}\hat{j}\right)$

BITSAT-2010

Ans. (b) : Given that,

Potential energy, U(x, y) = cos(x + y)

But we can represent a force field as,

$$\vec{F} = F_x\hat{i} + F_y\hat{j} \quad \text{.....(i)}$$

$$\vec{F} = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j}\right]$$

So,

$$F_x = -\frac{\partial U}{\partial x} = \sin(x+y)$$

$$\left[F_x\right]_{\left(0,\frac{\pi}{4}\right)} = \frac{1}{\sqrt{2}}$$

And $\quad F_y = -\frac{\partial U}{\partial y} = \sin(x+y)$

$$\left[F_y\right]_{\left(0,\frac{\pi}{4}\right)} = \frac{1}{\sqrt{2}}$$

Putting the value of F_x and F_y in equation (i), we get–

$$\vec{F} = \frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}$$

$$\vec{F} = \frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$$

@apna_pdf

318. A body of mass 5.0 kg is moving with linear momentum 10 kg-ms^{-1}. A force of 0.2 N is applied on the body for 10 s in the direction of motion of body. The increase in kinetic energy of body will be

(a) 2.8 J (b) 3.2 J
(c) 3.6 J (d) 4.4 J

CG PET- 2011

Ans. (d) : Given that,
Mass of body (m) = 5.0 kg
Momentum (p) = 10 kg-ms^{-1}
Force (F) = 0.2 N, Time (t) = 10 s

$$\because \quad p = mu$$

$$\therefore \quad u = \frac{p}{m} = \frac{10}{5} = 2\,m/s$$

From the first equation of motion–

$$v = u + at$$

$$v = u + \frac{F}{m}t \qquad \left(\because\ a = \frac{F}{m}\right)$$

$$v = 2 + \frac{0.2}{5}\times 10 = 2.4\ m/s$$

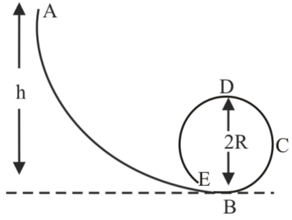
The increase in kinetic energy

$$= \frac{1}{2}m\left(v^2 - u^2\right)$$

$$= \frac{1}{2}\times 5\left[(2.4)^2 - (2)^2\right]$$

$$= \frac{1}{2}\times 5[5.76 - 4] = 4.4\,J$$

319. A frictionless track A, B, C, D, E end in a circular loop of radius R. A body slides down the track from point A which is at a height h = 5cm. Maximum value of R for the body to successful complete the loop is



(a) 5 cm (b) $\frac{15}{4}$cm
(c) $\frac{10}{3}$cm (d) 2 cm

CG PET- 2007

Ans. (d) : Given that,
Height of track (h) = 5 cm
Radius of circular loop = R
Potential energy of the body at point A= Kinetic energy of the body at point B

$$mgh = \frac{1}{2}mv^2$$

$$gh = \frac{v^2}{2} \qquad \text{....(i)}$$

Velocity at lowest point in a vertical circle

$$v = \sqrt{5Rg}$$

Putting the value of v in equation (i), we get–

$$gh = \frac{5Rg}{2}$$

$$R = \frac{2h}{5} \qquad [\because h = 5\text{ cm}]$$

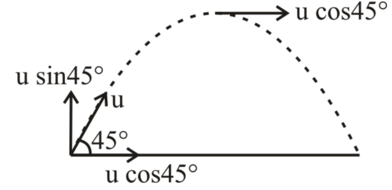
$$\therefore \quad R = \frac{2\times 5}{5} = 2\,\text{cm}$$

320. A ball is projected with kinetic energy (KE) at an angle of 45º to the horizontal. At the highest point during its flight, its kinetic energy will be

(a) zero (b) $\frac{KE}{2}$
(c) $\frac{KE}{\sqrt{2}}$ (d) KE

AIPMT-2001
CG PET- 2005

Ans. (b) :



Let u is the projection velocity.

Then, (KE) = $\frac{1}{2}mu^2$

Velocity of the ball at the highest point = u cos45°

$$= \frac{u}{\sqrt{2}}$$

Therefore, kinetic energy at the highest point

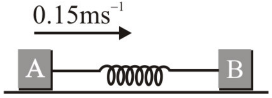
$$KE' = \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2$$

$$KE' = \frac{1}{2}\left(\frac{1}{2}mu^2\right)$$

$$KE' = \frac{1}{2}KE$$

$$KE' = \frac{KE}{2}$$

321. Two rectangular blocks A and B of masses 2 kg and 3 kg respectively are connected by a spring of spring constant 10.8 Nm^{-1} and are placed on a frictionless horizontal surface. The block A was given an initial velocity of 0.15 ms^{-1} in the direction shown in the figure, The maximum compression of the spring during the motion is



(a) 0.01 m (b) 0.02 m
(c) 0.05 m (d) 0.03 m

Manipal UGET-2009

@apna_pdf

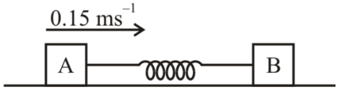
Ans. (c) : Given that,

$m_A = 2$ kg

$m_B = 3$ kg

$k = 10.8\ Nm^{-1}$

$u_A = 0.15$ m/s



According to law of conservation of linear momentum

$m_A u = (m_A + m_B)v$

$$v = \frac{m_A u}{m_A + m_B} = \frac{2\times 0.15}{2+3}$$

$v = 0.06$ m/s

Now,

Applying law of conservation of energy

$$\frac{1}{2}m_A u^2 = \frac{1}{2}(m_A + m_B)v^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}\times 2\times(0.15)^2 = \frac{1}{2}\times 5\times(0.06)^2 + \frac{1}{2}kx^2$$

$$0.0225 = 2.5 \times 0.0036 + \frac{1}{2}kx^2$$

$$\frac{1}{2}kx^2 = 0.0225 - 0.009$$

$$\frac{1}{2}kx^2 = 0.0135$$

$$kx^2 = 0.0270$$

$$x^2 = \frac{0.0270}{10.8} = 0.0025 \qquad (\because k = 10.8\ N/m)$$

$$x = \sqrt{0.0025}$$

$x = 0.05$ m

322. If we throws a body upwards with velocity of 4 m/s, at what height does its kinetic energy reduce to half of the initial value? (Take g = 10 ms^{-2})

(a) 4 m (b) 2 m

(c) 1 m (d) 0.4 m

JCECE-2007

Ans. (d) : Given,

Velocity of the body = 4 m/s

Let the mass of the body be m and height of the body at which its kinetic energy reduced to half of the initial value be h.

Then,

$$\text{Initial kinetic energy of the body (KE)} = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}\times m\times 4^2$$

$KE = 8m$

At height h,

$$\frac{1}{2}(KE) = mgh$$

$$mgh = \frac{8\times m}{2} = 4\ m$$

$$h = \frac{4\times m}{m\times g} = \frac{4}{g} = \frac{4}{10}$$

$h = 0.4$ m

323. An object of mass m is attached to light string which passes through a hollow tube. The object is set into rotation in a horizontal circle of radius r_1. If the string is pulled shortening the radius to r_2. The ratio of new kinetic energy to the original kinetic energy is:

(a) $\left(\frac{r_2}{r_1}\right)^2$ (b) $\left(\frac{r_1}{r_2}\right)^2$

(c) $\frac{r_1}{r_2}$ (d) $\frac{r_2}{r_1}$

JCECE-2005

Ans. (b) : We know,

Rotational kinetic energy of a particle

$$(K) = \frac{1}{2}I\omega^2 \qquad \text{.... (i)}$$

Where, $\omega = \frac{v}{r}$

r = Radius of circle

v = Linear velocity

ω = Angular velocity

I = Moment of inertia

From equation (i),

$$K = \frac{1}{2}I\left(\frac{v}{r}\right)^2$$

So, original kinetic energy is

$$K_1 = \frac{1}{2}I\frac{v^2}{r_1^2}$$

New kinetic energy is

$$K_2 = \frac{1}{2}I\frac{v^2}{r_2^2}$$

So, required ratio is-

$$\frac{K_2}{K_1} = \frac{r_1^2}{r_2^2} = \left(\frac{r_1}{r_2}\right)^2$$

324. A particle with total energy E is moving in a potential energy region $u(x)$. Motion of the particle is restricted to the region when

(a) $u(x) < E$ (b) $u(x) = 0$

(c) $u(x) \le E$ (d) $u(x) > E$

COMEDK 2013

Ans. (c) : Given,

A particle with total energy E is moving in a potential energy region u (x).

We know that,

Total Energy = Potential energy + Kinetic energy

$E = u(x) + KE(x)$

$KE(x) = E - u(x)$

It means when particle is moving kinetic energy must be positive.

$KE(x) \ge 0$

Then,

$E - u(x) = KE(x) \ge 0$

$E \ge u(x)$

Therefore,

$u(x) \le E$

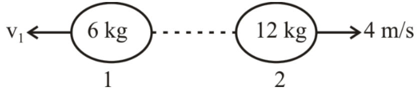
@apna_pdf

325. A bomb of mass 18 kg at rest explodes into two pieces of masses 6 kg and 12 kg. The velocity of 12 kg mass is 4 m/s. The kinetic energy of the other mass is

(a) 288 J (b) 192 J
(c) 96 J (d) 144 J

COMEDK 2015

Ans. (b) : Given ,
Mass of bomb (m) = 18kg
Velocity of 18 kg bomb (v) = 0 m/s
Mass of second bomb (m_2) = 12kg
Velocity of second bomb (v_2) = 4 m/sec
Mass of first bomb (m_1) = 6 kg
Velocity of first bomb (v_1) = ?



By using law of conservation of momentum,

$$mv = m_1v_1 + m_2v_2$$
$$18 \times 0 = (6 \times v_1) + (12 \times 4)$$
$$0 = 6v_1 + 48$$
$$6v_1 = -48$$
$$v_1 = -\frac{48}{6}$$
$$v_1 = -8 \text{ m/sec}$$

Kinetic energy of 6 kg mass (K.E.) = $\frac{1}{2}m_1(v_1)^2$

$$\text{K.E.} = \frac{1}{2}\times 6\times(-8)^2$$
$$\text{K.E.} = \frac{1}{2}\times 6\times 8\times 8$$
$$\text{K.E.} = 192 \text{ Joule}$$

326. Assertion: If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.

Reason: During collision intermolecular space decreases and hence elastic potential energy increases.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2011

Ans. (a) : If collision occurs between two elastic bodies then kinetic energy of bodies decreases because, at time of collision intermolecular space of bodies decrease.
Intermolecular attraction and repulsion lead to change in potential energy. It means, decreasing the intermolecular space lead to decrease the elastic potential.

327. Assertion: n small balls each of mass m colliding elastically each second on surface with velocity u. The force experienced by the surface is 2 mnu.

Reason: On elastic collision, the ball rebounds with the same velocity.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2010

Ans. (a): In elastic collision, kinetic energy remains conserved. Therefore, the ball rebounds with the same velocity.
Given,
Mass = m kg, velocity = u m/s
We know,
In elastic collision change in momentum

$$\Delta p = mu - (-mu)$$
$$= 2mu$$

For n balls,

$$\Delta p = n(2mu) = 2n\,mu$$

According to Newton's second law –

$$F = \frac{\Delta p}{t} = \frac{2nmu}{1}$$
$$F = 2nmu$$

328. Assertion: Frictional forces are conservative forces.

Reason: Potential energy can be associated with frictional forces.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

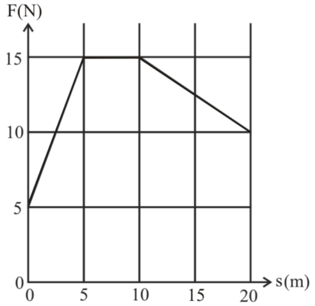
AIIMS-2005

Ans. (d) : Potential energy is conservative. Frictional force is non-conservative force as work done against frictional force can not be stored as potential energy. Hence, potential energy cannot be associated with frictional forces.

Note- As we know, conservative force are those force which depend upon the initial and final position while non-conservative force depend upon the path.

329. Figure here shows the frictional force versus displacement for a particle in motion. The loss of kinetic energy in travelling over s = 0 to 20 m will be

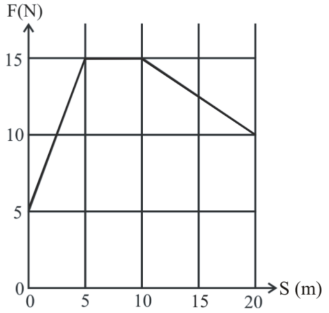
@apna_pdf



(a) 250 J (b) 200 J
(c) 150 J (d) 10 J

AIIMS-2015

Ans. (a) : Given,



We know that,
Loss of kinetic energy = Work done by the frictional force
Loss of kinetic energy = Area under the F v/s S curve

$$(\text{K.E.})_{\text{loss}} = \left[\frac{(5+15)}{2}\times 5\right] + [15\times 5] + \left[\frac{(15+10)}{2}\times 10\right]$$

$$(\text{K.E.})_{\text{loss}} = \left[\frac{20}{2}\times 5\right] + [15\times 5] + \left[\frac{25}{2}\times 10\right]$$

$(\text{K.E.})_{\text{loss}} = (10 \times 5) + 75 + (25 \times 5)$
$(\text{K.E.})_{\text{loss}} = (50 + 75 + 125)$ J
$(\text{K.E.})_{\text{loss}} = 250$ J

330. The potential energy of a certain particle is given by $U = \frac{1}{2}(x^2 - z^2)$. The force on it is:

(a) $-x\hat{i} + z\hat{k}$ (b) $x\hat{i} + z\hat{k}$
(c) $\frac{1}{2}(x\hat{i} + z\hat{k})$ (d) $\frac{1}{2}(x\hat{i} - z\hat{k})$

AIIMS-2011

Ans. (a) : Given, potential energy of a certain particle $(U) = \frac{1}{2}(x^2 - z^2)$.

Now, $F_x = -\frac{dU}{dx}$

$$F_x = -\frac{d}{dx}\left(\frac{x^2 - z^2}{2}\right)$$

$$F_x = -\frac{1}{2}[2x - 0]$$

$$F_x = -\frac{2x}{2} = -x$$

And, $F_z = -\frac{d}{dz}\left(\frac{x^2 - z^2}{2}\right)$

$$F_z = -\frac{1}{2}[0 - 2z]$$

$$F_z = \frac{2z}{2} = z$$

Therefore, $\vec{F} = F_x\hat{i} + F_z\hat{k}$

$$\vec{F} = -x\hat{i} + z\hat{k}$$

331. A ball loses 15.0% of its kinetic energy when it bounces back from a concrete wall. With what speed you must throw it vertically down from a height of 12.4 m to have it bounce back to the same height (ignore air resistance)?

(a) 6.55 m/s (b) 12.0 m/s
(c) 8.6 m/s (d) 4.55 m/s

AIIMS-2010

Ans. (a) : Given, height (h) = 12.4m
A ball loses 15.0% of its kinetic energy when it bounces back from a concrete wall.
From the equation of motion–

$v^2 = u^2 + 2gh$
$v^2 = u^2 + (2 \times 10 \times 12.4)$
$v^2 = u^2 + (2 \times 124)$
$v^2 = u^2 + 248$

Kinetic energy of the ball (K.E.) $= \frac{1}{2}mv^2$

$$= \frac{1}{2}m(u^2 + 248)$$

A ball loss 15.0% of its kinetic energy

$$\text{K.E.}' = \left(\frac{100-15}{100}\right)\times\frac{1}{2}m(u^2 + 248)$$

$$\text{K.E.}' = \frac{85}{100}\times\frac{1}{2}m(u^2 + 248)$$

Let v_1 be the upward velocity just after the collision with the ground.

$$\frac{1}{2}mv_1^2 = \frac{85}{100}\times\frac{1}{2}m(u^2 + 248)$$

$$v_1^2 = \frac{85}{100}(u^2 + 248)$$

Now, taking upward motion -
$v^2 = u^2 - 2gh$

$$0 = \frac{85}{100}(u^2 + 248) - 2\times 10\times 12.4 \qquad (v = 0, u = v_1)$$

$$\frac{85}{100}(u^2 + 248) = 248$$

$$u^2 + 248 = \frac{248\times 100}{85}$$

$u^2 = 291.76 - 248$
$u = \sqrt{43.76} = 6.61$ □ 6.55 m/s

@apna_pdf

332. For inelastic collision between two spherical rigid bodies:

(a) the total kinetic energy is conserved
(b) the total potential energy is conserved
(c) the linear momentum is not conserved
(d) the linear momentum is conserved

AIIMS-2006
MP PMT-2007

Ans. (d) : An inelastic collision two spherical rigid bodies the linear momentum is conserved. Thus, the kinetic energy of particles no longer remains conserved. However, in the absence of external forces law of conservation of linear momentum still holds good.

333. A bullet of mass 10g leaves a rifle at an initial velocity of 1000 m/sec and strikes the earth at the same level with a velocity of 500 m/sec. The work in Joule to overcoming the resistance of air will be:

(a) 500 J	(b) 5000 J
(c) 3750 J	(d) 475 J

AIIMS-2000

Ans. (c) : Given, mass of bullet (m) = 10g = 10 × 10^{-3} kg = 10^{-2} kg, initial velocity (v_i) = 1000 m/sec, final velocity (v_f) = 500 m/sec

Work done in overcoming the air resistance = ΔKE

Work done (W) = $(K.E.)_i - (K.E.)_f$

$$W = \frac{1}{2}m(v_i^2 - v_f^2)$$

$$W = \frac{1}{2}\times 10^{-2}\left[(1000)^2 - (500)^2\right]$$

$$W = \frac{1}{2}\times\frac{1}{100}\left[1000000 - 250000\right]$$

$$W = \frac{1}{200}\times 750000$$

$$W = \frac{7500}{2}$$

W = 3750 J

334. A body of mass 5 kg has momentum of 10 kg m/sec. When a force of 0.2 N is applied on it for 10 sec, the change in its kinetic energy is

(a) 4.4 J	(b) 3.3 J
(c) 5.5 J	(d) 1.1 J

AIIMS-2000

Ans. (a) : Given, mass of body (m) = 5kg, initial momentum (p_i) = 10 kg m sec^{-1}, force (F) = 0.2 N, time (t) = 10 sec

We know that, impulse = F × t

Impulse = 0.2 × 10 = 2

∵ Impulse = Change in momentum

$F \times t = dp$
$2 = (p_f - p_i)$
$p_f - 10 = 2$
$p_f = 2 + 10 = 12$ kg m sec^{-1}

Initial kinetic Energy $(K.E.)_i = \dfrac{p_i^2}{2m}$

$$(K.E.)_i = \frac{(10)^2}{2\times 5}$$

$$(K.E.)_i = \frac{100}{10} = 10\text{ J}$$

And final kinetic energy $(K.E.)_f = \dfrac{p_f^2}{2m}$

$$(K.E.)_f = \frac{(12)^2}{2\times 5}$$

$$(K.E.)_f = \frac{144}{10} = 14.4\text{ J}$$

∴ Change in Kinetic Energy (ΔK.E.) = $(K.E.)_f - (K.E.)_i$

ΔK.E. = 14.4 – 10
ΔK.E. = 4.4 J

335. A metal ball of mass 2 kg moving with speed of 36 km/hr is having a collision with a stationary ball of mass 3 kg. If after collision, both the balls move together, the loss in kinetic energy due to collision is:

(a) 80 J	(b) 40 J
(c) 60 J	(d) 160 J

AIIMS-2001

Ans. (c) : Given, mass (m_1) = 2kg, velocity (v_1) = 36 km/hr = 36 × $\dfrac{5}{18}$ = 10 m/s, mass (m_2) = 3kg, velocity (v_2) = 0 m/sec

Let, v be the common velocity

∴ Applying to conservation of momentum–

$m_1v_1 + m_2v_2 = (m_1 + m_2)\,v$
$(2 \times 10) + (3 \times 0) = (2 + 3)\,v$
$20 + 0 = 5v$

$$v = \frac{20}{5} = 4\text{ m/sec}$$

Initial kinetic energy $(K.E.)_i = \dfrac{1}{2}m_1v_1^2 + \dfrac{1}{2}m_2v_2^2$

$$(K.E.)_i = \frac{1}{2}\times 2\times(10)^2 + \frac{1}{2}\times 3\times(0)^2$$

$(K.E.)_i = 100 + 0$
$(K.E.)_i = 100$ J

Final kinetic Energy $(K.E.)_f = \dfrac{1}{2}(m_1 + m_2)\,v^2$

$$(K.E.)_f = \frac{1}{2}\,(2 + 3)\,(4)^2$$

$$(K.E.)_f = \frac{5}{2}\times 16 = 40\text{ J}$$

∴ Loss of energy = $(K.E.)_i - (K.E.)_f$
= 100 – 40
= 60 J

336. Two bodies of masses m and 4 m are moving with equal kinetic energy. Then the ratio of their linear momentum will be:

(a) 1:1	(b) 2:1
(c) 4:1	(d) 1:2

AIIMS-1999

@apna_pdf

Ans. (d) : Given, masses of two bodies m and 4m

And, $K.E._1 = K.E._2 = K.E.$

Kinetic energy according to the question,

$$\frac{1}{2}mv_1^2 = \frac{1}{2}(4m)v_2^2$$

$$v_1^2 = 4v_2^2$$

$$v_1 = 2v_2$$

Now, $\dfrac{\text{Linear momentum}(p_1)}{\text{Linear momentum}(p_2)} = \dfrac{m(v_1)}{4m(v_2)}$

$$\frac{p_1}{p_2} = \frac{v_1}{4v_2}$$

Putting the value of v_1, we get–

$$\frac{p_1}{p_2} = \frac{2v_2}{4v_2}$$

$$\frac{p_1}{p_2} = \frac{1}{2}$$

$\therefore$ $p_1 : p_2 = 1 : 2$

337. If the water falls from a dam into a turbine wheel 19.6 m below (which have both KE + PE), then the velocity of water at the turbine is : (take g = 9.8 m/sec^2)

(a) 19.6 m/s
(b) 39.0 m/s
(c) 98.8 m/s
(d) 9.8 m/s

AIIMS-1998

Ans. (a) : Given, height (h) = 19.6 m, g = 9.8 m/sec^2

Let, mass of water = m, velocity of water = v

From the law of conservation of energy,

$$(-mgh) + \frac{1}{2}mv^2 = 0$$

$$mgh = \frac{1}{2}mv^2$$

$$\frac{1}{2}v^2 = gh$$

$$v^2 = 2gh$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2 \times 9.8 \times 19.6}$$

$$v = \sqrt{384.16}$$

$$v = 19.6 \text{ m/sec}$$

338. A bullet is fired from a rifle. If the rifle recoils freely, then the kinetic energy of the rifle will be:

(a) same as that of bullet
(b) more than that of bullet
(c) less than that of bullet
(d) none of these

AIIMS-1998

Ans. (c) : Rifle and the bullet have the same momentum.

$$m'v' = mv$$

Where,

m' = mass of rifle
v' = velocity of rifle
m = mass of bullet
v = velocity of bullet

$\therefore$ $v' = \dfrac{mv}{m'}$ ....(i)

Now, the kinetic energy is equal to the half of the product of the mass and square of the velocity.

Kinetic Energy of bullet, $(K.E)_{bullet} = \dfrac{1}{2}mv^2$

Kinetic Energy of rifle $(KE)_{rifle} = \dfrac{1}{2}m'v'^2$

Put the value of v' from equation (i)

$$(K.E)_{rifle} = \frac{1}{2}m' \times \left(\frac{mv}{m'}\right)^2$$

$$(K.E)_{rifle} = \frac{m}{m'} \times \frac{1}{2}mv^2$$

$$(K.E)_{rifle} = \frac{m}{m'} \times KE_b$$

The mass of the rifle is larger than the bullet,

$$\frac{m}{m'} < 1$$

$\therefore$ Kinetic energy of rifle < Kinetic energy of bullet

Hence, the kinetic energy of rifle less than kinetic energy of bullet.

339. The potential energy of 1kg particle free to move along the X-axis is given by–

$$\mathbf{U = \left(\frac{x^4}{4} - \frac{x^2}{2}\right)J}$$

The total mechanical energy of the particle is 2J. Maximum speed of the particle is–

(a) $\dfrac{3}{\sqrt{2}}$
(b) $\dfrac{1}{\sqrt{2}}$
(c) $\sqrt{2}$
(d) 2

BCECE-2016

Ans. (a) : Given,

Mass of particle (m) = 1kg

Total mechanical energy (M.E) = 2J

The potential energy (U) = $\left(\dfrac{x^4}{4} - \dfrac{x^2}{2}\right)J$

Force (F) = $\dfrac{dU}{dx}$

$$\frac{dU}{dx} = \frac{d}{dx}\left(\frac{x^4}{4} - \frac{x^2}{2}\right)$$

$$\frac{dU}{dx} = \frac{1}{4}\frac{d}{dx}x^4 - \frac{1}{2}\frac{d}{dx}x^2$$

$$\frac{dU}{dx} = \frac{4}{4}x^3 - \frac{2}{2}x$$

$$\frac{dU}{dx} = x^3 - x$$

$$F = \frac{dU}{dx} = 0$$

$$x^3 - x = 0$$

@apna_pdf

$$x(x^2-1)=0$$

$$x=0$$

and $$x^2-1=0$$

$$x=\pm 1$$

$$\frac{dU}{dx}=x^3-x$$

$$\frac{d^2U}{dx^2}=3x^2-1$$

$\because$ $$\frac{d^2U}{dx^2}=\text{positive}$$

$\therefore$ Potential energy is minimum

Then, $U=\left(\frac{x^4}{4}-\frac{x^2}{2}\right)$ at, $x=\pm 1$

Then,

$$U=\left(\frac{(1)^4}{4}-\frac{(1)^2}{2}\right)$$

$$U=\frac{1}{4}-\frac{1}{2}$$

$$U=-\frac{1}{4}$$

Now, Total energy = Kinetic energy + Potential energy

$$E=K_{max}+U$$

$$K_{max}=E-U=2-\left(-\frac{1}{4}\right)$$

$$K_{max}=2+\frac{1}{4}$$

$$K_{max}=\frac{8+1}{4}$$

$$K_{max}=\frac{9}{4}$$

$$\frac{1}{2}mv_{max}^2=\frac{9}{4}$$

$$v_{max}^2=\frac{9\times 2}{4m}$$

$$v_{max}^2=\frac{9}{2m} \qquad [m = 1\text{ kg (given)}]$$

$$v_{max}^2=\frac{9}{2\times 1}$$

$$v_{max}=\sqrt{\frac{9}{2}}$$

$$v_{max}=\frac{3}{\sqrt{2}}\text{ m/sec}$$

340. A body of mass 1kg is moving in a vertical circular path of radius 1m. The difference between the kinetic energies at its highest and lowest positions is–

(a) $4\sqrt{5}$J (b) 20J

(c) 10J (d) 30J

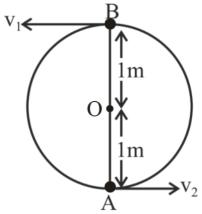
BCECE-2015

Ans. (b) : Given,

Mass of body (m) = 1kg

Radius (r) = 1m

Acceleration due to gravity (g) = 10m/sec^2



Velocity at the highest point (i.e. point B)

$$v_{top}=v_1=\sqrt{gr}$$

$\therefore$ Kinetic Energy (KE$_1$) = $\frac{1}{2}mv_1^2$

$$KE_1=\frac{1}{2}m\left(\sqrt{gr}\right)^2$$

$$KE_1=\frac{1}{2}m\,gr$$

$$KE_1=\frac{1}{2}\times 1\times 10\times 1$$

$$KE_1=5\text{ J}$$

Velocity at the bottom point (i.e. point A)

$v_{bottom}=v_2=\sqrt{5gr}$

$\therefore$ Kinetic energy (KE$_2$) = $\frac{1}{2}mv_2^2$

$$KE_2=\frac{1}{2}m\left(\sqrt{5gr}\right)^2$$

$$KE_2=\frac{1}{2}m(5gr)$$

$$KE_2=\frac{5}{2}mgr$$

$$KE_2=\frac{5}{2}\times 1\times 10\times 1$$

$$KE_2=25\text{ J}$$

$\therefore$ Difference in kinetic energy

$= KE_2 - KE_1$

$= 25 - 5$

$= 20$ J

341. Moment of inertia of wheel about the axis of rotation is 3MKS units. Its kinetic energy will be 600J, if period of rotation is (in seconds) –

(a) π (b) $\frac{\pi}{5}$

(c) $\frac{\pi}{10}$ (d) 2π

BCECE-2014

Ans. (c) : Given,

Moment of Inertia (I) = 3 kg-m^2

Kinetic Energy (KE) = 600 J

Let, ω is the angular velocity

We know that,

@apna_pdf

$$KE = \frac{1}{2} I.\omega^2$$

$$\omega^2 = \frac{2\,KE}{I}$$

$$\omega = \sqrt{\frac{2\,KE}{I}}$$

$$\omega = \sqrt{\frac{2 \times 600}{3}}$$

$$\omega = \sqrt{2 \times 200}$$

$$\omega = \sqrt{400}$$

$\omega = 20$ radian/sec

$$\because \quad \omega = 2\pi n$$

$$\omega = 2\pi \frac{1}{T}$$

$$\left[\because n = \frac{1}{T}, n = \text{Frequency, } T = \text{Time period}\right]$$

$$T = \frac{2\pi}{\omega}$$

$$T = \frac{2\pi}{20}$$

$$T = \frac{\pi}{10}$$

Hence, period of rotation of the wheel is $\frac{\pi}{10}$ sec.

342. If the momentum of a body is increased by n times, then its kinetic energy increases

(a) n times (b) n^2 times

(c) 2n times (d) $\sqrt{n}$ times

BCECE-2012

Ans. (b) : We know that,

$$K.E = \frac{1}{2} mv^2 \qquad \ldots(i)$$

Momentum (p) = mv

From equation (i) –

$$K.E = \frac{1}{2}\frac{mv^2 \times m}{m} \qquad \text{(Divide and multiply by m)}$$

$$K.E = \frac{1}{2m}(mv)^2$$

$$2m.K.E. = (mv)^2$$

$$2m.\ K.E = p^2$$

$$K.E = \frac{p^2}{2m}$$

$$K.E \propto p^2$$

So, the momentum increased by n times –

$$K.E \propto (np)^2$$

$$K.E \propto n^2p^2$$

So, when the momentum of body increased by n times then its kinetic energy will increased by n^2 times.

343. A spring gun of spring constant 90 N/cm is compressed 12 cm by a ball of mass 16 g. If the trigger is pulled, the velocity of the ball is

(a) 50 ms^{-1} (b) 9 ms^{-1}

(c) 40 ms^{-1} (d) 60 ms^{-1}

(e) 90 ms^{-1}

Kerala CEE - 2008

Ans. (e) : Given,

Spring constant (k) = 90 N/cm, = 9000 N/m,

Mass (m) = 16 g = 16×10^{-3} kg

Compression in the spring x = 12 cm = 0.12 m

Potential energy stored in the spring (U)

$$U = \frac{1}{2}kx^2$$

$$U = \frac{1}{2} \times (9000)(0.12)^2$$

$$U = 64.8J$$

If the trigger is pulled then potential energy is converted into a kinetic energy of the ball.

$$U = K$$

$$U = \frac{1}{2}mv^2$$

$$64.8 = \frac{1}{2}mv^2$$

$$64.8 = \frac{1}{2}(16 \times 10^{-3})v^2$$

$$8100 = v^2$$

$$v = \sqrt{8100}$$

$$v = 90 \text{ m/s}$$

344. In vertical circular motion, the ratio of kinetic energy of a particle at highest point to that at lowest point is

(a) 5 (b) 2

(c) 0.5 (d) 0.2

MHT-CET 2016

Ans. (d) : Velocity at the lowest point of the vertical circular motion $v_L = \sqrt{5gr}$ $(\because r = \text{radius})$

Kinetic energy at lowest point, $(K.E.)_L = \frac{1}{2}m(v_L)^2$

And,

Velocity at the highest point of the vertical circular motion

$$v_h = \sqrt{gr}$$

Kinetic energy at highest point $(K.E.)_h = \frac{1}{2}m(v_h)^2$

Ratio,

$$\frac{(K.E.)_h}{(K.E.)_L} = \frac{\frac{1}{2}m(v_h)^2}{\frac{1}{2}m(v_L)^2}$$

$$= \frac{(v_h)^2}{(v_L)^2} = \frac{\left(\sqrt{gr}\right)^2}{\left(\sqrt{5gr}\right)^2} = \frac{gr}{5gr} = \frac{1}{5}$$

$$\frac{(K.E.)_h}{(K.E.)_L} = 0.2$$

@apna_pdf

345. When the speed of the particle increases by 2 units, the kinetic energy becomes doubled. What is the original speed of the particles?

(a) 2 units (b) $\sqrt{2}$ units

(c) $2\left(\sqrt{2}+1\right)$units (d) $\sqrt{2}\left(\sqrt{2}+1\right)$units

SCRA-2010

Ans. (c) : Let,
The original speed of particle = v

Kinetic energy of particle (KE) $= \frac{1}{2}mv^2$ ….(i)

According to the question,
Increasing speed of particle = (v + 2)
Then kinetic energy becomes doubled = 2 KE

$$2KE = \frac{1}{2}m(v+2)^2 \quad ….(ii)$$

From equation (i) and (ii), we get-

$$\frac{1}{2}m(v+2)^2 = mv^2$$
$$\frac{1}{2}(v+2)^2 = v^2$$
$$(v+2)^2 = 2v^2$$
$$(v+2) = \sqrt{2v^2}$$
$$v+2 = \sqrt{2}v$$
$$2 = \sqrt{2}v - v$$
$$2 = v\left(\sqrt{2}-1\right)$$
$$v = \frac{2}{\sqrt{2}-1}$$
$$v = \frac{2\left(\sqrt{2}+1\right)}{\left(\sqrt{2}-1\right)\times\left(\sqrt{2}+1\right)}$$
$$v = 2\left(\sqrt{2}+1\right) \text{ units}$$

346. The kinetic energy of a body of mass 4 kg and momentum 6 N-s will be :

(a) 4.5 J (b) 2.5 J

(c) 5.5 J (d) 3.5 J

Karnataka CET-2015

Ans. (a) : Given,
Mass of body (m) = 4 kg.
Momentum (p) = 6 N-s
Kinetic energy (E) = ?

We know, the relation between kinetic energy and momentum

$$p = \sqrt{2mE}$$
$$6 = \sqrt{2\times4\times E}$$
$$6 = 2\sqrt{2E}$$
$$\sqrt{2E} = 3$$
$$2E = 3^2$$
$$2E = 9$$
$$E = \frac{9}{2} = 4.5 \text{ J.}$$

Hence, kinetic energy is 4.5 J.

347. A solid sphere of mass m rolls down an inclined plane without slipping, starting from rest at the top of an inclined plane. The linear speed of the sphere at the bottom of the inclined plane is v. The kinetic energy of the sphere at the bottom is:

(a) $\frac{1}{2}mv^2$ (b) $\frac{5}{3}mv^2$

(c) $\frac{2}{5}mv^2$ (d) $\frac{7}{10}mv^2$

Karnataka CET-2011

Ans. (d) : The kinetic energy of the solid sphere at the bottom is
Total kinetic energy, $K = K_r + K_R$

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid sphere –

$$I = \frac{2}{5}mR^2$$

So,

$$K = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mR^2\right)\omega^2$$
$$K = \frac{1}{2}mv^2 + \frac{1}{5}mv^2 \qquad (\because v = R\omega)$$
$$K = mv^2\left[\frac{1}{2}+\frac{1}{5}\right]$$
$$K = \frac{7}{10}mv^2$$

Hence,

Kinetic energy of the sphere at the bottom is $\frac{7}{10}mv^2$.

348. A body of mass 5 kg is thrown vertically up with a kinetic energy of 490 J. The height at which the kinetic energy of the body becomes half of the original value is :
(acceleration due to gravity = 9.8 ms^{-2})

(a) 5 m (b) 2.5 m

(c) 10 m (d) 12.5 m

Karnataka CET-2011

Ans. (a) : Given,
Mass of body (m) = 5kg.
Kinetic energy (K.E.) = 490J
Acceleration due to gravity (g) = 9.8 m/s^2
We know that,

Kinetic energy, $K.E. = \frac{1}{2}mv^2$

$$v^2 = \frac{2(K.E.)}{m} = \frac{2\times490}{5} = 2\times98$$

Let h be the maximum height,

$$h = \frac{v^2}{2g} = \frac{2\times98}{2\times9.8} = 10m$$

Also, $K.E. = \frac{1}{2}m(2gh)$ ….(i)

@apna_pdf

Let h' be the height at which the K.E of the body becomes half. (i.e. $m' = m/2$)

$$K.E.' = \frac{1}{2}m(2gh') \qquad ....(ii)$$

Dividing equation (ii) and (i) we get-

$$\frac{K.E.'}{K.E.} = \frac{h'}{h} \qquad [\because K.E.' = K.E./2]$$

$$\therefore \quad \frac{K.E.}{2K.E.} = \frac{h'}{h}$$

$$h' = \frac{h}{2} = \frac{10}{2} = 5m$$

349. Two bodies of masses 1 kg and 2 kg have equal momentum. Then, the ratio of their kinetic energies is :

(a) 2 : 1
(b) 3 : 1
(c) 1 : 3
(d) 1 : 1

Karnataka CET-2004, 2012

Ans. (a) : Given,

Mass $(m_1) = 1$ kg.
Mass $(m_2) = 2$kg.

Let, the bodies of masses 1 kg and 2 kg have kinetic energy is E_1 and E_2 respectively and have equal momentum.

Then $\quad E_1 = \frac{p^2}{2m_1}$

$$E_2 = \frac{p^2}{2m_2}$$

Ratio between E_1 and E_2 –

$$\frac{E_1}{E_2} = \frac{p^2/2m_1}{p^2/2m_2}$$

$$\frac{E_1}{E_2} = \frac{p^2 2m_2}{p^2 2m_1}$$

$$\frac{E_1}{E_2} = \frac{m_2}{m_1}$$

$$\frac{E_1}{E_2} = \frac{2}{1} \qquad \begin{bmatrix} \because m_1 = 1kg \\ m_2 = 2kg. \end{bmatrix}$$

$E_1 : E_2 = 2 : 1$

350. For a moving particle (mass m, velocity V) having a momentum p, which one of the following correctly describes the kinetic energy of the particle

(a) $\frac{p^2}{2m}$
(b) $\frac{p}{2m}$
(c) $\frac{V^2}{2m}$
(d) $\frac{V}{2m}$

J&K CET- 2011

Ans. (a) : We know that,

Kinetic energy of particle $= \frac{1}{2}mv^2$ …(i)

Momentum (p) = mv

$$v = \frac{p}{m} \qquad ...(ii)$$

Putting the value of equation (ii) in equation (i) we get –

$$K.E. = \frac{1}{2}m\left(\frac{p}{m}\right)^2 = \frac{1}{2}m \times \frac{p^2}{m^2}$$

$$K.E. = \frac{1}{2} \times \frac{p^2}{m} = \frac{p^2}{2m}$$

351. If the force acting on a body is inversely proportional to its speed, then its kinetic energy is

(a) Linearly related to time
(b) Inversely proportional to time
(c) Inversely proportional to the square of time
(d) A constant

J&K CET- 2009

Ans. (a) : Given, Force = F , speed = v

According to the question, $F \propto \frac{1}{v}$

$$F = \frac{C}{v} ....(i) \qquad (\because C = \text{constant})$$

We know that, $F = m\frac{dv}{dt}$

From equation (i), we get–

$$m\frac{dv}{dt} = \frac{C}{v}$$

$$v.\,dv = \frac{C}{m}dt$$

Integration on both side, we get–

$$\int v.dv = \int \frac{C}{m}dt$$

$$\frac{v^2}{2} = \frac{C}{m} \times t + C \qquad (C = \text{integration constant})$$

Multiply 'm' on both sides, we get–

$$\frac{1}{2}mv^2 = Ct + Cm$$

$$K.E = Ct + Cm$$

Or $\quad K.E. \propto t$

So, kinetic energy is directly proportional to time linearly.

352. A body moving with velocity v has momentum and kinetic energy numerically equal. What is the value of v?

(a) 2 m/s
(b) $\sqrt{2}$ m/s
(c) 1 m/s
(d) 0.2 m/s

J&K CET- 2004

Ans. (a) : Given, velocity = v,

Let, momentum = p, and kinetic energy = K. E.

$\because$ Momentum (p) = mv

Kinetic energy $= \frac{1}{2}mv^2$

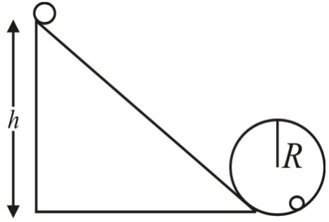
According to the question both are numerically equal.

$$mv = \frac{1}{2}mv^2$$

$$v = 2m/s$$

@apna_pdf

353. A body slides without friction from a height h along a track shown in figure, so that it completes the loop in the vertical plane. If the radius of the loop is R, what should be the minimum value of h in terms of R so that the body is just able to completes the loop. There is no friction between the body and the track.

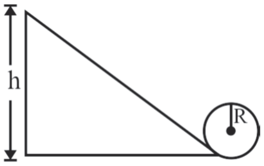


(a) h = R (b) h =2R

(c) $h = \frac{5}{2}R$ (d) h = 4R

J&K CET- 2001

Ans. (c) :



We know that, minimum velocity at the bottom of the circle to complete the loop = $\sqrt{5gR}$

So, for a body falling from height h –

$$\text{Velocity} = \sqrt{2gh}$$

$$\therefore \quad \sqrt{2gh} = \sqrt{5gR}$$

Both side square

$$2gh = 5gR$$

$$h = \frac{5}{2}R$$

354. A pendulum bob of mass m is suspended by a string of length *l*. The bob is pulled to one side so that it is a height above its freely hanging level. If the bob is now released from rest, the speed of the bob at its lowest point is given by

(a) mg*l*/8 (b) $\sqrt{mgl/2}$

(c) $\sqrt{2gl}$ (d) $\sqrt{gl/8}$

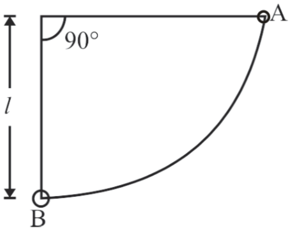
J&K CET- 1997

Ans. (c) : Given,

Mass of pendulum bob = m

Length of string = *l*

The bob is at rest at the point A. When it released from A, the bob passes through the lowest point B.



Now, Potential energy at point A = mg*l*

Kinetic energy at point B = $\frac{1}{2}mv^2$

Energy at extreme position = energy at mean position

$$mgl = \frac{1}{2}mv^2$$

$$gl = \frac{v^2}{2}$$

$$v^2 = 2gl$$

$$v = \sqrt{2gl}$$

355. A massless spring of spring constant k, has extension y and potential energy E. It is now stretched from y to 2y. The increase in its potential energy is

(a) 3E (b) 2E

(c) E (d) 4E

J&K-CET-2016

Ans. (a) : Given,

Spring constant = k
Extension = y
Potential energy = E

So,

$$\text{Potential energy (E) of the spring} = \frac{1}{2}ky^2 \quad \text{.............(i)}$$

Now, it is stretched from y to 2y, so

$$\text{Potential energy } (E') = \frac{1}{2}k(2y)^2$$

$$= \frac{1}{2}k4y^2$$

$$\text{Potential energy } (E') = 2ky^2 \quad \text{.....(ii)}$$

From equation (i), we get

$$E = \frac{1}{2}ky^2 \times \frac{2}{2}$$

$$E = \frac{1}{4}\times\left(2ky^2\right)$$

$$4E = E' \qquad \left(\because E' = 2ky^2\right)$$

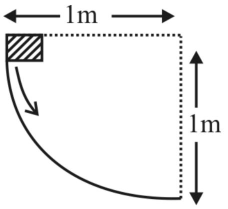
$\therefore$ Increase in its potential energy (ΔE) = E' – E

$$\Delta E = 4E - E$$

$$\Delta E = 3E$$

Hence, increasing potential energy is 3E.

356. A body of mass 2 kg slides down a curved track which is quadrant of a circle of radius 1 m as shown in figure. All the surface are frictionless. If the body starts from rest its speed at the bottom of the track is



(a) 2 ms^{-1} (b) 0.5 ms^{-1}

(c) 19.6 ms^{-1} (d) 4.43 ms^{-1}

JCECE-2012
J&K CET-1999

@apna_pdf

Ans. (d) : Given, mass of body = 2 kg, height = 1m.
$g = 9.8\ m/s^2$
According to the conservation law of energy
$\because$ Potential energy = Kinetic energy

$$mgh = \frac{1}{2}mv^2$$
$$mv^2 = 2mgh$$
$$v = \sqrt{2gh}$$
$$v = \sqrt{2 \times 9.8 \times 1}$$
$$v = \sqrt{19.6}$$
$$v = 4.43 ms^{-1}$$

357. For the same kinetic energy, the momentum is maximum for
(a) An electron (b) A proton
(c) A deuteron (d) An α particle

AMU-2002

Ans. (d) : As we know that relation between kinetic energy and momentum.

$$K.E. = \frac{p^2}{2m}$$
$$\therefore \quad \text{Momentum } (p) = \sqrt{2mK.E.}$$
$$p \propto \sqrt{m}$$

So, for the same kinetic energy the momentum is maximum for an α particle.

358. The potential energy of a body is given by $U = A - Bx^2$ (where x is the displacement)
The magnitude of force acting on the particle is
(a) Constant
(b) Proportional to x
(c) Proportional to x^2
(d) Inversely proportional to x

JIPMER-2012

Ans. (b) : Given that, $U = A - Bx^2$

$$\because \text{ Force } F = -\frac{dU}{dx}$$
$$F = -\frac{d}{dx}\left(A - Bx^2\right)$$
$$F = 2\ Bx$$
$$F \propto x$$

Hence, the magnitude of force acting on the particle is directly proportional to x.

359. A particle is acted upon by a constant power. Then, which of the following physical quantity remains constant?
(a) Speed
(b) Rate of change of acceleration
(c) Kinetic energy
(d) Rate of change of kinetic energy

WB JEE 2013

Ans. (d) : Power (P) = Rate of doing work $= \frac{dW}{dt}$

$$P = \frac{dW}{dt} = \text{Rate of change in K.E.}$$
$$\text{i.e.} \quad P = \frac{dW}{dt} = \frac{d(K.E.)}{dt} = \text{Constant}$$

So, power is constant then rate change of kinetic energy is also constant.

360. Two particles have masses m and 4m and their kinetic energies are in the ratio 2: 1. What is the ratio of their linear moment?
(a) $1/\sqrt{2}$ (b) 1/2
(c) 1/4 (d) 1/16

WB JEE 2009

Ans. (a) : Given, $m_1 = m,\ m_2 = 4m$

Ratio of their kinetic energy $\frac{(K.E.)_1}{(K.E.)_2} = \frac{2}{1}$

$$\because \quad K.E. = \frac{p^2}{2m}$$
$$\frac{(K.E.)_1}{(K.E.)_2} = \left(\frac{p_1}{p_2}\right)^2 \times \frac{m_2}{m_1} \quad \ldots(i)$$

Putting the value of mass and kinetic energy in equation (i), we get -

$$\frac{2}{1} = \left(\frac{p_1}{p_2}\right)^2 \times \frac{4m}{m}$$
$$\frac{p_1}{p_2} = \frac{1}{\sqrt{2}}$$

361. A sphere of diameter 0.2 m and mass 2 kg is rolling on an incline plane with velocity v=0.5 m/s. The kinetic energy of the sphere is
(a) 0.1 J (b) 0.3 J
(c) 0.5 J (d) 0.42 J

UP CPMT-2004

Ans. (d) : Given that,
$m = 2kg,\ v = 0.5\ m/s,\ d = 0.2m \Rightarrow r = 0.1\ m$

For sphere, $I = \frac{2}{3}mr^2$

K.E. = Translational kinetic energy + Rotational Kinetic energy

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$
$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{3}mr^2\right) \times \left(\frac{v}{r}\right)^2$$
$$= \left(\frac{1}{2} \times 2 \times (0.5)^2\right) + \frac{1}{2}\left(\frac{2}{3} \times 2 \times (0.1)^2\right) \times \left(\frac{0.5}{0.1}\right)^2$$
$$= 0.25 + 0.17$$
$$= 0.42J$$

362. In the stable equilibrium position, a body has
(a) maximum potential energy
(b) minimum potential energy
(c) minimum kinetic energy
(d) maximum kinetic energy

UP CPMT-2012

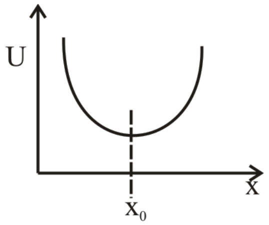
@apna_pdf

Ans. (b) : For stable equilibrium, the second derivative should be positive. so, for slight displacement , the restoring force should act on the body.

$$\frac{d^2U}{dx^2} > 0$$

Where,

dU → Potential energy, dx → displacement



Equilibrium position (x_0), stable equilibrium when $U(x_0)$ is a minimum.

363. A body moving with a speed v can be stopped over a distance x. If its kinetic energy is doubled, how much would be the stopping distance, for the same retarding force?

(a) 2x (b) 4x

(c) 8x (d) 16x

SRM JEE - 2007

Ans. (a) : Given,

Speed = v, Stopping distance = x

We know,

$$\text{Kinetic energy of body}(K.E) = \frac{1}{2}mv^2 \quad \dots (i)$$

Now,

Kinetic energy is doubled,

$$2(K.E) = \frac{1}{2}mv'^2 \quad \dots (ii)$$

From equation (i) and (ii), we get

$$v' = \sqrt{2}v \quad \dots (iii)$$

Now, from third equation of motion,

$$v^2 - u^2 = 2as$$

$$0 - v^2 = -2ax \quad [\text{Final velocity } (v) = 0]$$

$$v^2 = 2ax \quad \dots (iv)$$

When kinetic energy is doubled, let new stopping distance be x'. So,

$$\left(\sqrt{2}v\right)^2 = 2ax' \quad \dots (v)$$

Dividing equation (iv) by equation (v), we get

$$\frac{1}{2} = \frac{x}{x'}$$

$$x' = 2x$$

364. A body of mass 5 kg falls from a height of 30m. If whole of its mechanical energy is changed into heat, then heat produced will

(a) 1400 cal (b) 700 cal

(c) 350 cal (d) 175 cal

SRM JEE - 2009

Ans. (c) : Given ,

Mass (m) = 5 kg

Height (h) = 30 m

Mechanical energy of the body (E) = mgh

E = 5 × 9.8 × 30 J

$$\text{Heat produced (H)} = \frac{5\times9.8\times30}{4.2}\text{cal} \qquad [1\,\text{cal} = 4.2\,\text{J}]$$

$$= 350 \text{ cal}$$

365. The kinetic energy of a body of mass 2 kg and momentum of 2N s is

(a) 1 J (b) 2 J

(c) 3 J (d) 4 J

SRM JEE - 2013

Ans. (a) : Given, mass (m) = 2 kg, momentum (p) = 2 N-s

We know that momentum (p) is related to kinetic energy (K.E) as –

$$K.E = \frac{p^2}{2m} = \frac{(2)^2}{2\times2}$$

$$K.E = 1J$$

366. For a body moving in a horizontal circular path with uniform speed, which of the following remains unchanged?

(a) velocity (b) acceleration

(c) direction of velocity (d) kinetic energy

MP PET -2013

Ans. (d) : A body moving in a horizontal circular path with uniform speed its kinetic energy remains unchanged.

$$K.E. = \frac{1}{2}mv^2$$

Hence, speed is uniform. So, K.E. remains unchanged

367. Potential energy of a particle is related to x coordinate by equation $x^2 - 2x$. Particle will be in stable equilibrium at:

(a) x = 0.5 (b) x = 1

(c) x = 2 (d) x = 4

MP PET-2012

Ans. (b) : The Potential energy relation is –

$$U(x) = x^2 - 2x$$

For stable equilibrium,

$$F = -\frac{dU}{dx}$$

$$F = \frac{-d\left(x^2 - 2x\right)}{dx}$$

$$F = -2x + 2$$

If particle is in equilibrium then net force (F_{net}) will be zero.

$$\therefore \quad F_{net} = 0$$

$$-2x + 2 = 0$$

$$x = \frac{2}{2}$$

Hence, x = 1

@apna_pdf

368. The potential energy of a molecule increases when it is brought to the surface from the interior of a liquid because

(a) At the free liquid surface gravitational potential energy is more
(b) Work has to be done to move a molecule to the surface against the repulsive component of the inter molecular forces
(c) Work has to be done to move a molecule to the surface against the attraction from other molecules
(d) The temperature of the liquid surface is always more than that of the interior of the liquid

MP PMT-2009

Ans. (b) : The molecules on the liquid surface experience net downward force. But liquid molecule inside liquid is attracted by neighboring molecule from all sides. To bring a molecule from interior of liquid to the free surface, some work is required to be done against the intermolecular force of attraction which will be stored as potential energy of the molecule on the surface. Therefore, work has to be done to move a molecule to surface.

369. A gas expands 0.25 m^3 at constant pressure 10^3 N/m^2, the work done is

(a) 250 N (b) 250 W
(c) 250 J (d) 2.5 erg

JIPMER-2013

Ans. (c): Given,

Pressure (P) = 10^3 N/m^2
Volume (ΔV) = 0.25 m^3

We know that,

$$W = P\Delta V$$
$$W = 10^3 \times 0.25$$
$$W = 250 \text{ J}$$

370. A shell of mass 20 kg at rest explodes into two fragments whose masses are in the ratio 2:3. The smaller fragment moves with a velocity of 6m/s. The kinetic energy of the larger fragment is.

(a) 96 J (b) 216 J
(c) 144 (d) 360 J

JIPMER-2012

Ans. (a) : Given, $m_1 = 8$ kg , $v_1 = 6$ m/s
$m_2 = 12$ kg , $v_2 = ?$

The ratio of the two masses is 2 : 3. Then, the masses of the fragments are 8 kg and 12 kg.

According to law of conservation of momentum,

$$m_1 v_1 = m_2 v_2$$
$$8 \times 6 = 12 \times v_2$$
$$v_2 = \frac{8 \times 6}{12}$$
$$v_2 = 4 \text{ m/sec}$$

So, the kinetic energy of larger fragment –

Kinetic energy (K.E.) $= \frac{1}{2} m_2 v_2^2$

$$\text{K.E.} = \frac{1}{2} \times 12 \times (4)^2$$
$$\text{K.E.} = 6 \times 16$$
$$\text{K.E.} = 96 \text{ J}$$

371. The potential energy of a molecule on the surface of a liquid compared to one inside the liquid is

(a) zero (b) lesser
(c) equal (d) greater

JIPMER-2009

Ans. (d) : The molecules at the surface of a liquid have lower number of neighbouring atoms because they do not have any molecule above them compared to the molecules in the bulk which have surrounding molecules in every direction.

But when the surface area of liquid is increased, molecules from the interior of the liquid rise to the surface. As these molecules reach the surfaces, work is done against the cohesive forces between the interior molecules of the liquid.

Now, these molecules have less number of neighbour and the work done is stored in the molecules in the form of potential energy. Thus, the molecules lying at the surface is greater than that of the molecules in the interior of the liquid.

372. If we throw a body upwards with velocity of 4 m/s, at what height does its kinetic energy reduce to half of the initial value?
(Take g = 10 ms^{-2})

(a) 4 m (b) 2 m
(c) 1 m (d) 0.4 m

JIPMER-2008

Ans. (d) : Given,

Velocity (v) = 4 m/s , Final kinetic energy (K_f) = $\frac{1}{2}$K

Acceleration due to gravity (g) = 10 m/s^2

We know that,

Kinetic energy $(\text{K.E.})_i = \frac{1}{2} mv^2$

$$K = (\text{K.E.})_i = \frac{1}{2} m(4)^2 = 8m \qquad \text{.....(i)}$$

And potential energy = mgh

According to conservation of energy theorem,

$$-mgh = -\frac{1}{2}K$$

Putting the value of K from equation (i) , we get –

$$mgh = \frac{1}{2}(8m)$$
$$gh = 4$$
$$h = \frac{4}{10} = 0.4\text{m}$$

373. A sphere of diameter 0.2 m and mass 2 kg is rolling on an inclined plane with velocity v = 0.5 m/s. The kinetic energy of the sphere is

(a) 0.1 J (b) 0.3 J
(c) 0.5 J (d) 0.42 J

JIPMER-2005

Ans. (d) : Given that,

Diameter of sphere (d) = 0.2 m
and radius r = d / 2 = 0.1m
Mass (m) = 2 kg
Velocity (v) = 0.5 m/s

@apna_pdf

Kinetic energy of sphere = Translational kinetic energy + Rotational kinetic energy

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of sphere (I) = $\frac{2}{5}mr^2$ and $\omega = \frac{v}{r}$

$$=\frac{1}{2}\times 2(0.5)^2 + \frac{1}{2}\times\frac{2}{3}mr^2\times\left(\frac{0.5}{0.1}\right)^2$$

$$=0.25+\frac{1}{3}\times 2\times(0.1)^2\times\frac{0.25}{0.01}$$

$$=0.25+\frac{1}{3}\times 2\times 0.25$$

$= 0.25 + 0.17$

$= 0.42$ J

374. A mobile phone of mass 100 g falls from the hand of a person through the window of a train. The train is accelerating at 1 m/s^2 and just 20 seconds have passed since it has left the station from standstill. If the window is 2 m above the ground, with what kinetic energy the phone will hit the ground (g = 10 m/s^2)?

(a) 11 J (b) 22 J

(c) 33 J (d) 44 J

Assam CEE-2016

Ans. (b) : Given, m = 100 g = 0.1 kg, h = 2m, t = 20sec and a = 1 m/s^2

Now, velocity of train,

$v = u + at$

$v = 0 + 1 \times 20 = 20$ m/s

Now, kinetic energy when the phone will hit the ground,

K.E = Energy due to motion of train + energy due to height of window

$$= \frac{1}{2}mv^2 + mgh$$

$$= \frac{1}{2}\times 0.1\times(20)^2 + 0.1\times 10\times 2$$

$= 20 + 2$

K.E. = 22 J

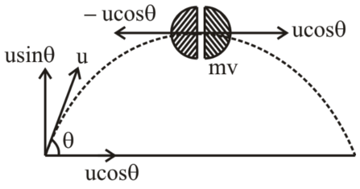
375. A cannon shell fired breaks into two equal parts at its highest point. One part retraces the path to the cannon with kinetic energy E$_1$ and kinetic energy of the second part is E$_2$. Relation between E$_1$ and E$_2$ is

(a) $E_2 = 15 E_1$ (b) $E_2 = E_1$

(c) $E_2 = 4E_1$ (d) $E_2 = 9E_1$

AP EAMCET -2014

Ans. (d) :



Initial mass = 2m,

Initial horizontal velocity = u cosθ

Initial momentum, $P_i = 2m\,u\cos\theta$

Final momentum, $P_f = -mu\cos\theta + mv$

By law of conservation of momentum along horizontal axis,

$P_i = P_f$

$2m\,u\cos\theta = -m\,u\cos\theta + mv$

$mv = 2mu\cos\theta + mu\cos\theta$

$mv = 3mu\cos\theta$

Final velocity $v = 3u\cos\theta$

Now,

$E_1 = \frac{1}{2}m(u\cos\theta)^2$ $[\because v_i = u\cos\theta]$

$E_1 = \frac{1}{2}mu^2\cos^2\theta$ .....(i)

$E_2 = \frac{1}{2}m(3u\cos\theta)^2$

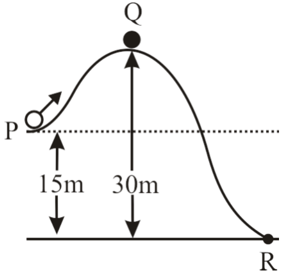
$E_2 = \frac{9}{2}mu^2\cos^2\theta$

$E_2 = 9[\frac{1}{2}mu^2\cos^2\theta]$

From equation (i)

$E_2 = 9E_1$

376. In the figure shown, a ball of mass 1.0 kg is rolled with a kinetic energy of 330 J. It reaches R through the path PQR. Find the speed of the ball at R, if its potential energy at P is zero.



(a) 52 m/s (b) 45 m/s

(c) 40 m/s (d) 31 m/s

AMU-2014

Ans. (d) : Given,

Mass of ball, m = 1.0 kg

KE at P = 330J

Let, speed of ball at point R = v_2

h = –15 m by energy conservation

$KE_{at\ P} + PE_{at\ P} = KE_{at\ R} + PE_{at\ R}$

$$330 + 0 = \frac{1}{2}mv_2^2 - mgh$$

$$330 = \frac{1}{2}mv_2^2 - 1\times 10\times 15$$

$$480 = \frac{1}{2}\times 1\times v_2^2 \qquad (\because m = 1)$$

$v_2^2 = 960$

$= 30.98$

$v_2 \approx 31$m/s

@apna_pdf

377. **A particle of mass 2 mg moves with constant speed and is found to pass two points 5.0 m apart in a time interval of 5 m.s. Find the kinetic energy of the particle**

(a) 1.0 J (b) 2.0 J
(c) 3.0 J (d) 4.0 J

AMU-2014

Ans. (a) : Given,
Mass of particle = 2mg or 2×10^{-3}g = 2×10^{-6} kg
d = 5m, t = 5 ms = 5×10^{-3} s

$$\text{Kinetic Energy }(\text{KE}) = \frac{1}{2}mv^2$$

$$\text{But, velocity }(v) = \frac{d}{t} = \frac{5}{5\times10^{-3}}$$

$$\Rightarrow \quad v = 10^3\,m/s$$

$$\therefore \quad KE = \frac{1}{2}\times(2\times10^{-6})\times(10^3)^2$$

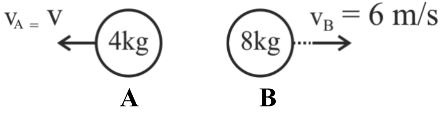
$$KE = 1.0\,J$$

378. **A 12 kg bomb explodes into two parts of 4 kg and 8 kg each. The velocity of 8 kg part is 6 m/sec. The kinetic energy of the other part is**

(a) 488 J (b) 288 J
(c) 144 J (d) 12 J

AMU-2004

Ans. (b) : The initial momentum of bomb was zero, therefore after explosion two parts should posses numerically equal momentum.



From conservation of momentum –

$m_A v_A - m_B v_B = 0$
$4 \times v - 8 \times 6 = 0$
$4v = 48$
$v = 12$ m/s

$$\text{Kinetic Energy (K.E)} = \frac{1}{2}mv^2$$

$$K.E = \frac{1}{2}\times 4\times 12\times 12, \quad K.E = 288\text{ J}$$

379. **An iron piece falls from a height of 1 km on the ground. If all the energy is converted into heat, the temperature of the iron piece will be (specific heat of iron = 0.1 kcal/kg°C)**

(a) 0.233°C (b) 2.33°C
(c) 23.3°C (d) 233°C

AMU-2002

Ans. (c) : When falling body gets heated
Potential Energy = Heat Energy

$mgh = mc\Delta T$
$gh = c\Delta T$

$$\Rightarrow \quad \Delta T = \frac{gh}{c}$$

$$\Delta T = \frac{9.8}{4.2\times(0.1\times1000)}$$

$$\Delta T = \frac{7\times10}{3}$$

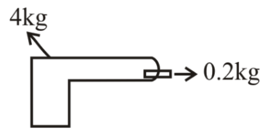
$\Delta T = 23.3$ºC

380. **A shell of mass 200 g is ejected from a gun of mass 4 kg by an explosion that generates 1.05 kJ of energy. The initial velocity of the shell is**

(a) 100 ms^{-1} (b) 80 ms^{-1}
(c) 40 ms^{-1} (d) 120 ms^{-1}

AIPMT- 2008

Ans. (a) : Given, m = 4 kg, $m_2 = 0.2$ kg



$$\text{From, } \frac{1}{2}m_1v_1^2 + \frac{1}{2}\times m_2v_2^2 = \text{Total energy}$$

$$\frac{1}{2}4v_1^2 + \frac{1}{2}\times0.2v_2^2 = 1050J.$$

$$2v_1^2 + 0.1v_2^2 = 1050 \qquad .....(i)$$

From law of conservation of momentum –

$-m_1v_1 + m_2v_2 = 0$
$-4v_1 + 0.2v_2 = 0$
$4v_1 = 0.2v_2$

$$v_1 = \frac{0.2}{4}v_2$$

$$v_1 = \frac{v_2}{20}$$

So, putting the value of v_1 in equation (i), we get –

$$2\left(\frac{v_2}{20}\right)^2 + \frac{v_2^2}{10} = 1050$$

$$2\left(\frac{v_2}{20}\right)^2 + \frac{v_2^2}{10} = 1050$$

$$v_2^2\left(\frac{1}{200} + \frac{1}{10}\right) = 1050$$

$$v_2^2\left(\frac{1+20}{200}\right) = 1050$$

$$\frac{21v_2^2}{200} = 1050$$

$$v_2^2 = 50\times200$$

$$v_2^2 = 10000$$

$v_2 = 100$ m/s

381. **A particle of mass m_1 is moving with a velocity v_1 and another particle of mass m_2 is moving with a velocity v_2. Both of them have the same momentum, but their different kinetic energies are E_1 and E_2 respectively. If $m_1 > m_2$, then**

(a) $E_1 < E_2$ (b) $\frac{E_1}{E_2} = \frac{m_1}{m_2}$
(c) $E_1 > E_2$ (d) $E_1 = E_2$

AIPMT- 2004

@apna_pdf

Ans. (a) :
Linear momentum, $P_1 = m_1 v_1$
Linear momentum, $P_2 = m_2 v_2$
$\because$ Equal momentum, $P_1 = P_2$
$\therefore$ $m_1 v_1 = m_2 v_2$

$$\frac{m_1}{m_2} = \frac{v_2}{v_1}$$

Then,

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}m_1 v_1^2}{\frac{1}{2}m_2 v_2^2}$$

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}(m_1 v_1) \times v_1}{\frac{1}{2}(m_2 v_2) \times v_2}$$

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}P_1 v_1}{\frac{1}{2}P_2 v_2} \qquad [\because P_1 = P_2]$$

$$\frac{E_1}{E_2} = \frac{v_1}{v_2} = \frac{m_2}{m_1} \qquad \left[\because \frac{m_1}{m_2} = \frac{v_1}{v_2}\right]$$

$$E_2 > E_1 \qquad (\because m_1 > m_2)$$

382. A stationary particle explodes into two particles of masses m_1 and m_2, which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1/E_2 is

(a) 1 (b) $\frac{m_1 v_2}{m_2 v_1}$

(c) $\frac{m_2}{m_1}$ (d) $\frac{m_1}{m_2}$

AIPMT- 2003

Ans. (c) : From law of conservation of momentum,

$$m \times (0) = m_1 v_1 + m_2(-v_2)$$

$$m_1 v_1 = m_2 v_2 \Rightarrow \frac{v_1}{v_2} = \frac{m_2}{m_1}$$

The ratio of kinetic energy will be,

$$\frac{E_1}{E_2} = \frac{\frac{1}{2}m_1 v_1^2}{\frac{1}{2}m_2 v_2^2}$$

$$\frac{E_1}{E_2} = \frac{m_1 v_1}{m_2 v_2} \cdot \frac{v_1}{v_2}$$

$$\frac{E_1}{E_2} = \frac{v_1}{v_2} \qquad [\because m_1 v_1 = m_2 v_2]$$

So,

$$\frac{E_1}{E_2} = \frac{m_2}{m_1} \qquad \left[\because \frac{v_1}{v_2} = \frac{m_2}{m_1}\right]$$

383. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water jet. What is the rate at which kinetic energy is imparted to water?

(a) $\frac{1}{2}mv^3$ (b) mv^3

(c) $\frac{1}{2}mv^2$ (d) $\frac{1}{2}m^2v^2$

AIPMT- 2009

Ans. (a) : Given that -
v = speed of the water
m = mass per unit length

$$\frac{dK}{dt} = ?$$

We know that,

Kinetic energy, $K = \frac{1}{2}Mv^2$

So,

$$\frac{dK}{dt} = \frac{d}{dt}\left(\frac{1}{2}Mv^2\right)$$

$$\frac{dK}{dt} = \frac{1}{2}v^2 \frac{dM}{dt}$$

$$\frac{dK}{dt} = \frac{1}{2}v^2\left(\frac{dM}{dl} \times \frac{dl}{dt}\right) \qquad \left[\because \frac{dM}{dl} = m\right]$$

$$\frac{dK}{dt} = \frac{1}{2} \times v^2(m \times v)$$

$$\frac{dK}{dt} = \frac{1}{2}mv^3$$

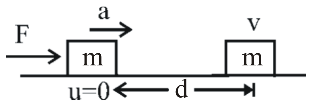
384. The KE acquired by a mass m in travelling a certain distance d, starting from rest, under the action of a constant force is directly proportional to

(a) m (b) $\sqrt{m}$

(c) $\frac{1}{\sqrt{m}}$ (d) Independent of m

AIPMT- 1994

Ans. (d) :



So, Kinetic Energy = Work done.
K.E = F.d
Hence, kinetic energy is independent of mass m.

385. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 m s^{-1}. The kinetic energy of the other mass is

(a) 256 J (b) 486 J

(c) 524 J (d) 324 J

AIPMT- 2005

Ans. (b) : Given,
$m_1 = 18,\ v_1 = 6$
$m_2 = 12,\ v_2 = ?$

@apna_pdf

According to law of conservation of momentum,

$$m_1v_1 = m_2v_2$$
$$(18) \times (6) = 12 \times (v_2)$$
$$v_2 = \frac{108}{12}$$
$$v_2 = 9 \text{ m/s}$$

Kinetic energy $= \frac{1}{2}m_2v_2^2$

$$= \frac{1}{2}\times 12\times(9)^2 = \frac{1}{2}\times 12\times 9\times 9$$

K.E. = 486 J

386. A ball of mass 2 kg and another of mass 4 kg are dropped together from a 60 ft tall building. After, a fall of 30 ft each towards earth, their respective kinetic energies will be in the ratio of

(a) $\sqrt{2}:1$ (b) 1:4

(c) 1:2 (d) $1:\sqrt{2}$

AIPMT- 2004

Ans. (c) : Given that,

$m_1 = 2\text{kg}$ $m_2 = 4\text{kg}$ $h = 60$ ft

According to Newton's third law of motion –

$$v^2 = u^2 + 2gh$$
$$v = \sqrt{2gh}$$

Velocity is constant for both the body because they are falling through the same height

$\therefore$ Kinetic Energy (K.E.) $= \frac{1}{2}mv^2$

$$\frac{(\text{K.E.})_1}{(\text{K.E.})_2} = \frac{\frac{1}{2}m_1v^2}{\frac{1}{2}m_2v^2}$$
$$\frac{(\text{K.E.})_1}{(\text{K.E.})_2} = \frac{m_1}{m_2}$$
$$\frac{(\text{K.E.})_1}{(\text{K.E.})_2} = \frac{2}{4} = \frac{1}{2}$$
$$(\text{K.E.})_1 : (\text{K.E.})_2 = 1:2$$

387. The potential energy of a particle in a force field is $U = \frac{A}{r^2} - \frac{B}{r}$, where A and B are positive constants and r is the distance of particle from the centre of the field. For stable equilibrium, the distance of the particle is

(a) B/2A (b) 2A/B

(c) A/B (d) B/A

AIPMT- 2012

Ans. (b) : We know that,

$$\vec{F} = -\frac{dU}{dr}$$

But given potential energy is,

$$U = \frac{A}{r^2} - \frac{B}{r}$$

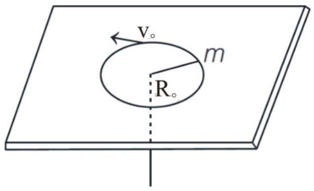
Both side differentiate

$$\frac{dU}{dr} = A\left(\frac{-2}{r^3}\right) - B\left(\frac{-1}{r^2}\right)$$
$$= \frac{-2A}{r^3} + \frac{B}{r^2}$$

In case of stable equilibrium, F = 0

$$= \frac{-2A}{r^3} + \frac{B}{r^2} = 0$$
$$r = \frac{2A}{B}$$

388. A mass m moves in a circle on a smooth horizontal plane with velocity $v_\circ$ at a radius $R_\circ$. The mass is attached to a string which passes through a smooth hole in the plane as shown.



The tension in the string is increased gradually and finally moves in a circle of radius $\frac{R_\circ}{2}$. The final value of the kinetic energy is

(a) $mv_\circ^2$ (b) $\frac{1}{4}mv_\circ^2$

(c) $2mv_\circ^2$ (d) $\frac{1}{2}mv_\circ^2$

AIPMT- 2015

Ans. (c) : We know angular momentum is conserved

Hence, $(mv_oR_o) = mv\left(\frac{R_o}{2}\right)$

$$mv_oR_o = \frac{mvR_o}{2}$$
$$v = 2v_o$$

Hence, the kinetic energy-

$$\text{K.E.} = \frac{1}{2}mv^2$$
$$\text{K.E.} = \frac{1}{2}m[2v_\circ]^2$$
$$\text{K.E.} = \frac{1}{2}m\times 4v_\circ^2$$
$$\text{K.E.} = 2\ mv_o^2$$

389. A block of mass 10 kg, is moving in x-direction with a constant speed of 10 ms^{-1}, is subjected to a retarding force F = – 0.1x J/m during its travel from x = 20 m to 30 m. Its final KE will be

(a) 475 J (b) 450 J

(c) 275 J (d) 250 J

AIPMT- 2015

@apna_pdf

Ans. (a) : The mass of block (m) = 10 kg
The block moves with velocity of (v) = 10 m/s
Retarding force (F) = – 0.1 x J/m during its travel from x = 20 m to x = 30 m
Work done = $(K.E.)_f - (K.E.)_i$

$$(K.E.)_f = W + (K.E.)_i$$

$$(K.E.)_f = \int_{x_1}^{x_2} F_x dx + \frac{1}{2}mv^2$$

$$= \int_{20}^{30} -0.1x\,dx + \frac{1}{2}\times 10\times(10)^2$$

$$= -0.1\left[\frac{x^2}{2}\right]_{20}^{30} + 500$$

$$= -0.1\left[\frac{900-400}{2}\right] + 500$$

$$= -25 + 500$$

$$(K.E.)_f = 475 \text{ J}$$

390. A particle of mass 10g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration, if the kinetic energy of the particle becomes equal to 8×10^{-4}J by the end of the second revolution after the beginning of the motion?

(a) 0.15 m/s^2 (b) 0.18 m/s^2
(c) 0.2 m/s^2 (d) 0.1 m/s^2

NEET- 2016

Ans. (d) : Given that, mass (m) = 10 g = 0.01 kg
Radius (r) = 6.4 cm = 6.4×10^{-2} m
K.E. = 8×10^{-4} J
Distance travelled by particle = $2\times2\pi r = 4\pi r$

$$\frac{1}{2}mv^2 = 8\times10^{-4}$$

$$v^2 = \frac{16\times10^{-4}}{0.01}$$

$$v^2 = 16\times10^{-2}$$

Initial velocity of particle (u) = 0 m/s
Now, we use 3rd equation of motion

$$v^2 = u^2 + 2a_ts$$

$$v^2 = 0 + 2\times a_t\times 4\pi r$$

$$a_t = \frac{v^2}{8\pi r}$$

$$a_t = \frac{16\times10^{-2}}{8\times3.14\times6.4\times10^{-2}}$$

$$a_t = 0.1 \text{ m/s}^2$$

391. A circular disc rolls down an inclined plane. The ratio of rotational kinetic energy to total kinetic energy is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$
(c) $\frac{2}{3}$ (d) $\frac{3}{4}$

DCE-2009

Ans. (b) : Total K.E. energy is
$(K.E.)_T$ = Rotational K.E. + Translational K.E
The ratio of rotational kinetic energy to total kinetic energy is

$$\frac{(K.E.)_R}{(K.E.)_T} = \frac{\frac{1}{2}I\omega^2}{\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2}$$

The moment of inertia of a circular disc = $\frac{1}{2}mr^2$ and $\omega = \frac{v}{r}$

$$\therefore \quad \frac{(K.E.)_R}{(K.E.)_T} = \frac{\frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2}{\frac{1}{2}\times\frac{1}{2}mr^2\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2}$$

$$\frac{(K.E.)_R}{(K.E.)_T} = \frac{\frac{1}{2}\left(\frac{1}{2}mv^2\right)}{\frac{1}{2}\left(\frac{1}{2}mv^2\right) + \frac{1}{2}mv^2}$$

$$\frac{(K.E.)_R}{(K.E.)_T} = \frac{1}{3}$$

392. A body of 200 g begins to fall from a height where its potential energy is 80 J. Its velocity at a point where kinetic and potential energies are equal is

(a) $10\sqrt{8}$ m/s (b) 4 m/s
(c) 400 m/s (d) 20 m/s

AP EAMCET(Medical)-2014

Ans. (d) : Given that, mass (m) = 200g = 0.2 kg From energy conservation –

T.E. = K.E. + P.E. [K.E. = P.E.]
T.E. = 2 K.E.
80 = 2 K.E.

$$K.E. = 40\text{ J} = \frac{1}{2}mv^2$$

$$mv^2 = 80 \qquad \ldots(i)$$

Putting the value of m in equation (i)
So,

$$0.2\,v^2 = 80$$

$$v^2 = \frac{80}{0.2}$$

$$v^2 = 400$$

$$v = \sqrt{400}$$

$$v = 20 \text{ m/s}$$

393. A solid sphere of radius 'r' is rolling on a horizontal surface. The ratio between the rotational kinetic energy and total energy.

(a) $\frac{5}{7}$ (b) $\frac{2}{7}$
(c) $\frac{1}{2}$ (d) $\frac{1}{7}$

AP EAMCET(Medical)-2015

@apna_pdf

Ans. (b) : We know,

Total Energy = Rotational K.E. + Translational K.E.

$$T.E. = (K.E.)_R + (K.E.)_T$$

$$\therefore \quad (K.E.)_R = \frac{1}{2}I\omega^2$$

Moment of inertia of solid sphere –

$$I = \frac{2}{5}mr^2$$

So,

$$(K.E.)_R = \frac{1}{2}\times\frac{2}{5}\ mr^2 \times \omega^2$$

$$(K.E.)_R = \frac{1}{5}\ mr^2\ \omega^2$$

$$(K.E.)_R = \frac{1}{5}\ mv^2 \qquad [\because v = r\omega]$$

Now,

$$(K.E.)_T = \frac{1}{2}mv^2$$

Hence,

The ratios are-

$$\frac{(K.E.)_R}{T.E.} = \frac{\left(\frac{1}{5}\right)mv^2}{\frac{1}{5}mv^2 + \frac{1}{2}mv^2}$$

$$\frac{(K.E.)_R}{T.E.} = \frac{\frac{1}{5}}{\frac{1}{5}+\frac{1}{2}} = \frac{1}{5}\times\frac{10}{7}$$

$$\frac{(K.E.)_R}{T.E.} = \frac{2}{7}$$

$$(K.E.)_R : T.E. = 2 : 7$$

394. The kinetic energy of a body rotating at 300 revolutions per minute is 62.8 J. Its angular momentum (in kg m^2s^{-1}) is approximately:

(a) 1 (b) 2
(c) 4 (d) 8

AP EAMCET(Medical)-2006

Ans. (c) : Given,

Kinetic energy (K.E) = 62.8 J

Revolution per minute (n) = 300 rpm.

$$n = \frac{300}{60}$$

$$n = 5 \text{ rps.}$$

Angular velocity $(\omega) = 2\pi n$

$$= 2\pi \times 5$$

$$= 10\pi$$

We know that,

Angular momentum (L) = I × ω

$$I = \frac{L}{\omega} \qquad \text{.....(i)}$$

Also, Kinetic energy (K.E.) $= \frac{1}{2}\ I\omega^2$ ....(ii)

On solving equation (i) & (ii), we get

$$K.E. = \frac{1}{2}\times\frac{L}{\omega}\times\omega^2$$

$$K.E. = \frac{1}{2}\times L\times\omega$$

$$62.8 = \frac{1}{2}\times 10\pi \times L$$

$$L = \frac{62.8}{5\pi}$$

$$L = \frac{62.8}{5\times3.14}$$

$$L = 4 \text{ kg } m^2s^{-1}$$

395. The kinetic energy of a body is four times its momentum. Its velocity is:

(a) 2 ms^{-1} (b) 4 ms^{-1}
(c) 8 ms^{-1} (d) 16 ms^{-1}

AP EAMCET(Medical)-1999

Ans. (c) : Given that,

K.E = 4 × momentum

K.E = 4 × mv

$$\frac{1}{2}mv^2 = 4\text{ mv}$$

$$\frac{1}{2}v = 4$$

v = 8 m/s

396. A mass of 12 kg at rest explodes into two pieces of masses 4 kg and 8 kg, which move in opposite directions. If the velocity of 8 kg piece is 6m/s, then the kinetic energy of the other piece in joule is:

(a) 64 (b) 128
(c) 144 (d) 288

AP EAMCET(Medical)-1997

Ans. (d) : Given that, mass (m) = 12 kg, initial velocity (v) = 0

$m_1 = 4$ kg, $m_2 = 8$ kg
$v_1 = ?$ $v_2 = 6$ m/s

Using law of conservation of linear momentum-

$$mv = m_1v_1 + m_2v_2$$

$$0 = 4v_1 + 48$$

$$v_1 = -12 \text{ m/s}$$

Now, $K.E = \frac{1}{2}m_1v_1^2$

$$= \frac{1}{2}\times 4\times(-12)^2$$

$$= \frac{1}{2}\times4\times12\times12$$

K.E = 288 J

397. A particle of mass 4 m which is at rest explodes into three fragments. Two of the fragments each of mass m are found to move with a speed of v each in mutually perpendicular direction. The total energy released in the process is

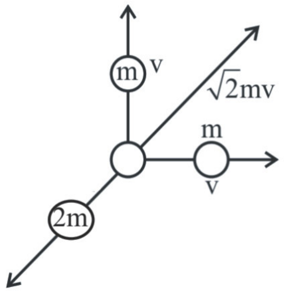
@apna_pdf

(a) $\frac{1}{2}mv^2$ (b) mv^2

(c) $\frac{5}{3}mv^2$ (d) $\frac{3}{2}mv^2$

AP EAMCET-1991

Ans. (d) : Given, $m_1 = m_2 = m$, $m_3 = 4m - 2m = 2m$



$\because$ $p_1 = p_2 = mv$

A pieces move perpendicular to each other, their resultant momentum–

$$p = \sqrt{p_1^2 + p_2^2} = \sqrt{(mv)^2 + (mv)^2} = mv\sqrt{2}$$

Principle of conservation of linear momentum gives–

$$p_3 = m_3 v_3 = p$$

or $$v_3 = \frac{mv\sqrt{2}}{m_3} = \frac{\sqrt{2}mv}{2m} = \frac{v}{\sqrt{2}}$$

Total Kinetic energy–

$$K.E. = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \frac{1}{2}m_3v_3^2$$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)\left(\frac{v}{\sqrt{2}}\right)^2$$

$$K.E. = \frac{3}{2}mv^2$$

398. A 2 kg body and 3 kg body have equal momentum. If the kinetic energy of 3 kg body is 10 J, the kinetic energy of 2 kg body will be, (in joule)

(a) 6.66 (b) 15

(c) 22.5 (d) 45

AP EAMCET-1993

Ans. (b) : Given that,

$m_1 = 2$ kg $(K.E)_2 = 10$ J

$m_2 = 3$ kg $(K.E)_1 = ?$

According to the question–

$p_1 = p_2$

From law of conversation of momentum –

Now, $$\frac{(K.E)_1}{(K.E)_2} = \frac{p_1^2}{p_2^2} \times \frac{2m_2}{2m_1} \quad .....(i)$$

Putting the value in eq^n. (i), we get –

$$\frac{(K.E)_1}{10\,J} = \frac{p_1^2}{p_2^2} \times \frac{2\times3}{2\times2} \quad (\therefore p_1 = p_2)$$

$$(K.E)_1 = 10 \times \frac{3}{2}$$

$$(K.E)_1 = 15\ J$$

399. Two bodies with kinetic energies in the ratio of 4 : 1 are moving with equal linear momentum. The ratio of their masses is

(a) 1 : 2 (b) 1 : 1

(c) 4 : 1 (d) 1 : 4

AP EAMCET-1995, 1996

Ans. (d) : Given that, linear momentum are equal (i.e. $p_1 = p_2$)

According to the question–

$$\frac{(K.E)_1}{(K.E)_2} = \frac{4}{1}$$

$$\frac{\frac{p^2}{2m_1}}{\frac{p^2}{2m_2}} = \frac{4}{1}$$

$$\frac{m_2}{m_1} = \frac{4}{1}$$

or $$\frac{m_1}{m_2} = \frac{1}{4}$$

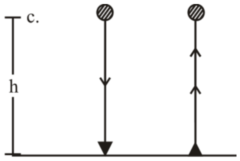
400. A ball is projected vertically down with an initial velocity from a height of 20 m on to a horizontal floor. During the impact it loses 50% of the energy and rebounds to the same height, the initial velocity of its projection is

(a) 20 ms^{-1} (b) 15 ms^{-1}

(c) 10 ms^{-1} (d) 5 ms^{-1}

AP EAMCET-2000

Ans. (a) : The ball project downward from point c at height (h)



So, energy at point c = $\frac{1}{2}mv^2 + mgh$

After collosion it loses 50% of energy and rebound again at same height h.

So, it posses only potential energy at same height–

$$\left(\frac{1}{2}mv^2 + mgh\right) \times 50\% = mgh$$

$$= \frac{1}{2}\left(\frac{1}{2}mv^2 + mgh\right) = mgh$$

$$\frac{1}{2}mv^2 + mgh = 2mgh$$

$$m\left(\frac{v^2}{2} + gh\right) = 2mgh$$

$$\frac{v^2}{2} + gh = 2gh$$

$$v^2 + 2gh = 4gh$$

$$v^2 = 4gh - 2gh$$

$$v^2 = 2gh$$

@apna_pdf

$$v = \sqrt{2gh}$$

$$v = \sqrt{2\times10\times20}$$

$$v = \sqrt{400}$$

$$v = 20\ \text{ms}^{-1}$$

401. A force of 5 N making an angle θ with the horizontal acting on an object displaces it by 0.4 m along the horizontal direction. If the object gains kinetic energy of 1 J the horizontal component of the force is

(a) 1.5 N (b) 2.5 N (c) 3.5 N (d) 4.5 N

AP EAMCET-2000

Ans. (b) : Given that, force = 5 N, s = 0.4m

According to the question–

K.E. = Work done (W) = 1J = 1 N.m

$$Fs\cos\theta = 1J$$

$$F\cos\theta = 1/0.4$$

Now, horizontal component of force (Fcosθ) = 1/0.4

= 2.5 N

402. Consider the following statements A and B and identify the correct answer given below

A. A body initially at rest is acted upon by a constant force. The rate of change of its kinetic energy varies linearly with time.

B. When a body is at rest, it must be in equilibrium.

(a) A and B are correct

(b) A and B are wrong

(c) A is correct and B is wrong

(d) A is wrong and B is correct

NDA (I)- 2011

AP EAMCET-2003

Ans. (c) : Kinetic Energy (KE) = $\frac{1}{2}mv^2$

$$= \frac{1}{2}m(at)^2 = \frac{1}{2}ma^2t^2$$

Rate of change of kinetic energy–

$$\frac{d(KE)}{dt} = \frac{d}{dt}\frac{1}{2}\left(ma^2t^2\right)$$

$$\frac{d(KE)}{dt} = \frac{1}{2}\times2\times ma^2t$$

$$\frac{d(KE)}{dt} = ma^2t$$

$$\frac{d(KE)}{dt} \propto t$$

So, rate of change of kinetic energy varies linearly with time. So, statement A is correct.

When a body is at rest then it may be or may not be in equilibrium. So, statement B is wrong.

403. A block of mass 2 kg is initially at rest on a horizontal frictionless surface. A horizontal force $\vec{F} = (9-x^2)\hat{i}$ Newton acts on it, when the block is at x = 0. The maximum kinetic energy of the block between x = 0 and x = 3 m in joule is

(a) 24 (b) 20

(c) 18 (d) 15

AP EAMCET-2004

Ans. (c) : Given that, $\vec{F} = (9-x^2)\hat{i}$

The block between $x_1 = 0$ to $x_2 = 3$

According to work energy theorem–

$$U = \int_{x_1}^{x_2} F.dx$$

$$U = \int_0^3 (9-x^2)dx = \left[9x - \frac{x^3}{3}\right]_0^3$$

= 18 J

404. A particle is moving freely. Then its

(a) kinetic energy is always greater than zero

(b) potential energy is greater than zero and kinetic energy is less than zero

(c) potential energy is less than zero and kinetic energy is greater than zero

(d) potential energy is zero and kinetic energy is less than zero

NDA (I) 2013

Ans. (a) : According to question, if particle is moving freely it means that it will have some velocity at any given instant. Hence K.E. of such particle will always positive. K.E. > 0

405. At a particular height, the velocity of an ascending body is u. The velocity at the same height while the body falls freely is

(a) 2 u (b) –u

(c) u (d) –2 u

WB JEE 2016

Ans. (b) : While moving up and moving down at a particular height, velocity of a body is same but in the opposite direction.

406. A ball is released from certain height which losses 50% of its kinetic energy on striking the ground, it will attain a height again

(a) $\left(\frac{1}{4}\right)^{th}$ of initial height

(b) $\left(\frac{1}{2}\right)^{th}$ of initial height

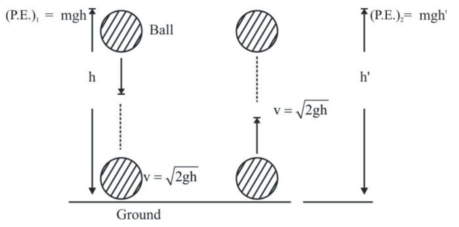
(c) $\left(\frac{3}{4}\right)^{th}$ of initial height

(d) None of the above

AP EAMCET (Medical) - 2012

JIPMER-2014

Ans. (b) :



Let ball dropped from height h. At height h, initial velocity of ball will be zero and at the ground, velocity of ball will be v.]

From 3rd equation of motion,

@apna_pdf

$v^2 = u^2 + 2as$

$v^2 = (0)^2 + 2gh$

$v^2 = 2gh$

$\boxed{v = \sqrt{2gh}}$

Kinetic Energy of ball at ground $(K.E.)_1 = \frac{1}{2}mv^2$

$$(K.E.)_1 = \frac{1}{2}\times m\times\left(\sqrt{2gh}\right)^2$$

$$(K.E.)_1 = \frac{1}{2}\times m\times(2gh)$$

$$(K.E.)_1 = mgh$$

After striking the ground, it losses 50% of its kinetic energy.

Then,

$$(K.E.)_2 = \frac{(K.E.)_1}{2}$$

$$(K.E.)_2 = \frac{mgh}{2}$$

Let after striking the ground, ball attains height h'. At height h',

Potential energy of the ball $(P.E.)_2 = mgh'$

From law of conservation of energy,

$$(P.E.)_2 = (K.E.)_2$$

$$mgh' = \frac{mgh}{2}$$

$$\boxed{h' = \frac{h}{2}}$$

407. A ball is falling freely from a height. When it reaches 10 m height from the ground its velocity is v_0. It collides with the ground and loses 50% of its energy and rises back to height of 10 m. Then the velocity v_0 is

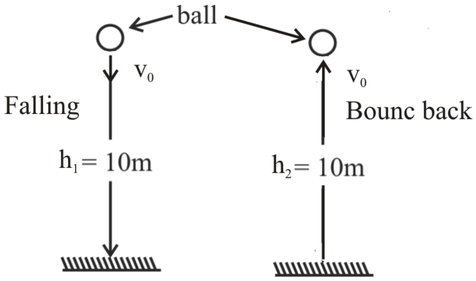
(a) 7 m/s (b) 10 m/s

(c) 14 m/s (d) 14 m/s

AP EAMCET -2010

Ans. (c) : Given,

$h_1 = h_2 = 10m$



From law of conservation of energy,

$$\frac{1}{2}\left(\frac{1}{2}mv_0^2 + mgh_1\right) = mgh_2$$

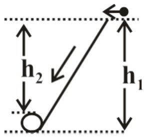
$$\frac{1}{2}v_0^2 + gh_1 = 2gh_2$$

$$\frac{1}{2}v_0^2 = g(2h_2 - h_1)$$

$$\frac{1}{2}v_0^2 = g\times 10$$

v_0= 14 m/s

408. A particle moves down an inclined plane and at the foot of the plane, it moves over a circular path as shown in figure. The ratio of the heights h_1 and h_2 is



(a) 5 (b) 4

(c) 3 (d) 2

Assam CEE-2014

Ans. (a) : We know,

Velocity at the bottom of the circle = $\sqrt{5gr}$

Velocity at the top of the circle = $\sqrt{gr}$

By using law of conservation of energy,

P.E. = K.E.

We get,

$$mgh_1 = \frac{1}{2}m(\sqrt{5gr})^2 = \frac{1}{2}m(5gr) \quad ...(i)$$

Also,

$$mgh_2 = \frac{1}{2}m(\sqrt{gr})^2 = \frac{1}{2}mgr \quad ...(ii)$$

From equation (i) and (ii),

$$\frac{h_1}{h_2} = 5$$

409. A truck accelerates from speed v to 2v. Work done in during this is :

(a) three times as the work done in accelerating it from rest to v

(b) same as the work done in accelerating it from rest to v

(c) four times as the work done in accelerating it from rest to v

(d) less than the work done in accelerating it from rest to v

Karnataka CET-2013

Ans. (a) : Work done (W) = ΔK.E = $\frac{1}{2}m\left(v_2^2 - v_1^2\right)$

Truck accelerates from v to 2v

$$W = \frac{1}{2}m\left[(2v)^2 - (v)^2\right] = \frac{3}{2}mv^2 \quad ....(i)$$

Truck accelerates from rest v_1 = 0 to v

$$W_1 = \frac{1}{2}m\left(v^2 - 0\right) = \frac{1}{2}mv^2 \quad ....(ii)$$

From equation (i) and (ii), we get

$W = 3W_1$

@apna_pdf

(c) Conservation of Energy and Work Energy Theorem

410. Power applied to a particle varies with time as ($P=3t^2-2t+1$) W, where t is in second. The change in its kinetic energy between t=2 s and t= 4 s is

(a) 32 J (b) 46 J
(c) 61 J (d) 100 J

CG PET 2019
Manipal UGET 2010

Ans. (b) : Given, Power (P) = $3t^2-2t+1$ watt
Since, power is time rate of change of work

(We know that), $P=\frac{dW}{dt}$

$dW = P.dt$ .....(i)

from work energy theorem

Work done(dW) = $(K.E.)_f - (K.E.)_i = \Delta K.E.$ ....(ii)

From equation (i) & (ii), we get –

$$\Delta K.E. = Pdt$$

$$\Delta K.E. = \int_{t=2}^{t=4} Pdt$$

$$= \int_{t=2}^{t=4} (3t^2-2t+1)dt$$

$$= \left[\frac{3t^3}{3}-\frac{2t^2}{2}+t\right]_{t=2}^{t=4} = \left[t^3-t^2+t\right]_{t=2}^{t=4}$$

$$= \left[(4^3-2^3)-(4^2-2^2)+(4-2)\right]$$

$$= 64 - 8 - 16 + 4 + 4 - 2 = 46 \text{ J}$$

411. A man of 60 kg is running on the road and suddenly jumps into a stationary trolley car of mass 120 kg. Then, the trolley car starts moving with velocity 2 ms^{-1}. The velocity of the running man was _____ ms^{-1}, when he jumps into the car.

JEE Main-28.06.2022, Shift-I

Ans. (6) : Given that,

$m_1 = 60\,kg, \quad m_2 = 120\,kg, \quad v_2 = 2\,m/s, \quad v_1 = ?$

By using the conservation of linear momentum–

$$m_1v_1 = (m_1+m_2)\times v_2$$

$$60\times v_1 = (60+120)\times 2$$

$$60v_1 = 360$$

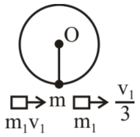
$$v_1 = \frac{360}{60}$$

v_1 = 6 m/s

412. A pendulum of length 2 m consists of a wooden bob of mass 50 g. A bullet of mass 75 g is fired towards the stationary bob with a speed v. The bullet emerges out of the bob with a speed $\frac{v}{3}$ and the bob just completes the vertical circle. The value of v is ____ ms^{-1}. (If g = 10 m/s^2)

JEE Main-27.06.2022, Shift-I

Ans. (10) : Given, mass of bob (M) = 50 gram
Mass of bullet (m_1) = 75 gram
Initial velocity of bob = 0
Length (l) = 2m



Velocity of bullet just before collision = v

Velocity after collision = $\frac{1}{3}\times v$

Let the velocity of bob just after collision is v_1 then law of conservation of moment an

$$m_1v = Mv_1 + m_1\frac{v}{3}$$

$$v_1 = \frac{2}{3}\frac{m_1v}{M}$$

For just computing the circle in vertical circular motion the velocity of v_1

$$v_1 = \sqrt{5gl}$$

$$\frac{2}{3}\frac{m_1v}{M} = \sqrt{5gl}$$

$$\therefore \quad v = \frac{3M}{2m_1}\sqrt{5gl}$$

$$v = \frac{3}{2}\times\frac{50}{75}\sqrt{5\times10\times2}$$

$$= \frac{150}{150}\sqrt{5\times10\times2} = \sqrt{100}$$

= 10 m/sec

413. A solid cylinder of mass m and R rolls down plane of height 30 m without slipping. The speed of its centre of mass when the cylinder reaches the bottom is
[use g = 10 m/s^2]

(a) 10 m/s (b) 20 m/s
(c) 30 m/s (d) 40 m/s

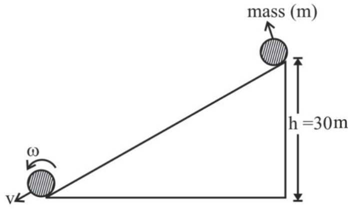
TS EAMCET 18.07.2022, Shift-II

Ans. (b) : Given, $g = 10$ m/s^2 , $h = 30$ m
Mass of cylinder = m
Radius of cylinder = R
At the case of rolling cylinder

$v = R\omega$ ....(i)

And

$I = \frac{1}{2}mR^2$ ....(ii)



To apply work energy theorem,
Potential energy = Kinetic energy + Rotational energy

@apna_pdf

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Putting the value of I from equation (ii), we get-

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{1}{2}mR^2\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}m(R\omega)^2 \qquad [\text{From equation (i)}]$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$mgh = \frac{3}{4}mv^2$$

$$v = \sqrt{\frac{4}{3}gh}$$

$$v = \sqrt{\frac{4}{3}\times 10\times 30}$$

$$v = \sqrt{400}$$

$v = 20$ m/s

414. A ball with 10^3J of kinetic energy collides with a horizontally mounted spring. If the maximum compression of the spring is 50 cm, then the spring constant of the spring is

(a) $2 \times 10^3\ Nm^{-1}$
(b) $6 \times 10^3\ Nm^{-1}$
(c) $8 \times 10^3 Nm^{-1}$
(d) $5 \times 10^3 Nm^{-1}$
(e) $3 \times 10^3 Nm^{-1}$

Kerala CEE 2021

Ans. (c) : Given,

Kinetic energy = 10^3J

Compression of spring(x_m) = 50 cm = 50×10^{-2} m

Let spring constant = K N/m

At maximum compression x_m, the kinetic energy of the ball is converted entirely into the potential energy of the spring.

$$K.E. = \frac{1}{2}Kx_m^2$$

$$10^3 = \frac{1}{2}K\left(50\times10^{-2}\right)^2$$

$$10^3 = \frac{1}{2}K\times\left(2500\times10^{-4}\right)$$

$$K = \frac{1000\times2}{2500\times10^{-4}}$$

$K = 8 \times 10^3$ N/m

415. An object released from certain height h from the ground rebounds to a height $\frac{h}{4}$ after striking the ground. The fraction of the energy lost by it is

(a) $\frac{1}{4}$
(b) $\frac{3}{4}$
(c) $\frac{1}{2}$
(d) $\frac{1}{8}$
(e) $\frac{3}{8}$

Kerala CEE 2021

Ans. (b) :

- Height from which the ball falls gives it a potential energy which converts to kinetic energy as the ball fall down.

$$(K.E.)_i = mgh$$

- When the ball finally hits the ground all the potential energy has convert to kinetic energy.

$$(K.E.)_f = \frac{mgh}{4}$$

Fraction of the energy loss $\Delta K = \frac{(K.E.)_i - (K.E.)_f}{(K.E.)_i}$

$$\Delta K = \frac{mgh - \frac{mgh}{4}}{mgh}$$

$$\Delta K = \frac{3}{4}$$

416. A body of mass M is dropped from a height h on a sand floor. If the body penetrates x cm into the sand, the average resistance offered by the sand to the body is ______.

(a) $Mg\left(\frac{h}{x}\right)$
(b) $Mg\left(\frac{x+h}{x}\right)$
(c) $Mg(h + x)$
(d) $Mg\left(\frac{x-h}{x}\right)$

AP EAMCET-23.08.2021, Shift-II

Ans. (b) : Work energy theorem when body reaches sand floor

Potential energy = kinetic energy

$$Mgh = \frac{1}{2}Mv^2$$

$$v = \sqrt{2gh}$$

When body penetrates to the sand it's KE will be dissipated by the resultant resistance force

$$\frac{1}{2}Mv^2 = (F - Mg)x$$

$$\frac{1}{2}M\left(\sqrt{2gh}\right)^2 = (F - Mg)x$$

$Mgh + Mgx = Fx$

$$F = Mg\left(\frac{x+h}{x}\right)$$

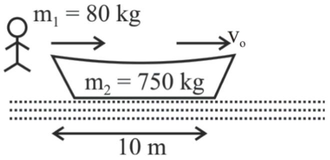
417. A 750 kg boat is 10 m long and is floating without motion on still water. A man of mass 80 kg is at one end and if he runs to another end of the boat and stops, the displacement of boat is

(a) 1.8 m in the direction of displacement of man
(b) 0.96m in the direction of opposite to the displacement of man
(c) 0.96 m in the direction of displacement of the man
(d) 1.8 m in the direction opposite to displacement of man

TS EAMCET 06.08.2021, Shift-I

@apna_pdf

Ans. (b) : Given,
Mass of man (m_1) = 80 kg
Mass of boat (m_2) = 750 kg
Length of boat (l_b) = 10 m



Displacement of man w.r.t. boat,

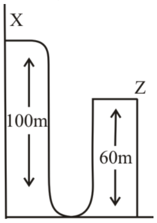
$$x = l_b\left(\frac{m_1}{m_1+m_2}\right) = -10\times\left(\frac{80}{80+750}\right)$$

$$= -10\times\left(\frac{80}{830}\right)$$

$$= -0.96 \text{ m}$$

Therefore, the displacement of the boat is 0.96 m in the direction of opposite to the displacement of man.

418. A car driver is trying to jump across a path as shown in figure by driving horizontally off a cliff 'X' at the speed 10 m/s. When he touches peak Z (ignore air resistance), what would be speed?
(use $g = 10\ m/s^2$)



(a) 30 m/s
(b) 40 m/s
(c) 15 m/s
(d) 50 m/s

TS EAMCET 04.08.2021, Shift-I

Ans. (a) : Here all forces are of conservative nature as we can neglect air resistance and no external force is acting on this system.
From energy conservation law,
If all forces are of conservative nature and no external force is acting on system, then mechanical energy at x and z will be equal–

$$(M.E.)_x = (M.E.)_z$$

$$mgh_x + \frac{1}{2}mv_x^2 = mgh_z + \frac{1}{2}mv_z^2$$

$$mg(100) + \frac{1}{2}m(10)^2 = mg(60) + \frac{1}{2}mv_z^2$$

$$100g + \frac{1}{2}\times 100 = 60g + \frac{1}{2}v_z^2 \qquad (g = 10m/s^2)$$

$$1000 + 50 = 600 + \frac{1}{2}v_z^2$$

$$2(1050-600) = v_z^2$$

$$900 = v_z^2$$

$$v_z = 30 \text{ m/s}$$

419. The Work-Energy theorem
(a) Does not hold in all inertial frames
(b) Is independent of Newton's second law
(c) May be viewed as a scalar form of Newton's second law
(d) Cannot be extended to non-inertial frames
(e) In independent of Newton's third law

Kerala CEE 2020

Ans. (c) : The Work-Energy theorem
The total work done by all the forces combined-done an object is equal to the change in the kinetic energy of the object. After the net force is removed (no more work is being done) the object's total energy is altered as a result of the work that was done.
May be viewed as a scalar form of Newton's second law.
Newton's second law state that,

$$F = ma = \frac{dB}{dt}$$

The work energy theorem statement,

$$\text{work done} = F.ds = \Delta K.E. = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

420. Which of the following statements is false?
(a) Momentum is conserved in all types of collisions
(b) Energy is conserved in all types of collisions
(c) During elastic collisions conservative forces are involved
(d) Work-energy theorem is not applicable to inelastic collisions

AP EAMCET-24.09.2020, Shift-I

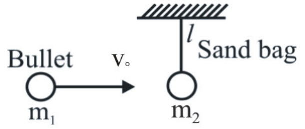
Ans. (d) : Momentum of all types of collisions are conserved $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
- Energy of all types of collision are conserved

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

- During elastic collisions conservative forces are involved.
- Work energy theorem is applicable for all type of collision.

Hence, option (d) is false.

421. A bullet of mass m_1 is moving with speed $v_\circ$ hits a sand bag of mass m_2. If the speed of the bullet after passing the sand bag is $\frac{v_O}{3}$, then the height h up to which the bag rises is (assume, g = acceleration due to gravity)



(a) $h = \frac{1}{2g}\left(\frac{2m_1v_O}{3m_2}\right)^2$
(b) $h = \frac{2m_1v_O}{3m_2}$
(c) $h = \frac{2}{2g}$
(d) $h = \left(\frac{2m_1v_O}{3m_2}\right)^2$

TS-EAMCET-09.09.2020, Shift-2

@apna_pdf

Ans. (a) : Given that,

Mass of bullet = m_1

Speed of bullet = v_o

Mass of sand bag = m_2

After passing the sand bag the speed of the bullet $= \frac{v_o}{3}$

∵ $p_i = p_f$

$$m_1 v_o = m_2 v_2 + m_1 \frac{v_o}{3}$$

$$m_1\left(v_o - \frac{v_o}{3}\right) = m_2 v_2$$

$$v_2 = \frac{2m_1 v_o}{3m_2} \quad \text{....(i)}$$

So, at this height the kinetic energy is equal to potential energy.

KE = PE

$$\frac{1}{2}m_2 v_2^2 = m_2 gh$$

$$h = \frac{1}{2g}v_2^2$$

From equation (i), we get-

$$h = \frac{1}{2g}\left(\frac{2m_1 v_o}{3m_2}\right)^2$$

422. A ball of mass 2g released from the top of an inclined plane describes a circular motion of radius 20 cm in the vertical plane upon reaching the bottom. The minimum height of the inclined plane is

(a) 20 cm (b) 10 cm

(c) 50 cm (d) 60 cm

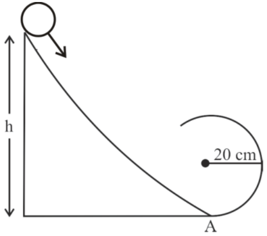
TS-EAMCET-09.09.2020, Shift-2

Ans. (c) : Given that,

Mass of ball (m) = 2 g

Radius (R) = 20cm

At the point A the potential energy of ball is converted into kinetic energy.



Kinetic energy = Potential energy

$$\frac{1}{2}mv^2 = mgh$$

$$v = \sqrt{2gh} \quad \text{...(i)}$$

The velocity of ball at a point A should be at least $\sqrt{5gR}$ to complete the vertical circle.

$$v_{min} \geq \sqrt{5gR}$$

Put the value of v from equation (i),

$$\sqrt{2gh} \geq \sqrt{5gR}$$

Squaring both side, we get –

$$h \geq \frac{5}{2}R$$

$$h_{min} = \frac{5}{2} \times 20 = 50\,\text{cm}$$

423. A bullet of mass 25 g moves horizontally at a speed of 250 m/s is fired into a wooden block of mass 1 kg suspended by a long string. The bullet crosses the block and emerges on the other side. If the centre of the mass of the block rises through a height of 20 cm. The speed of the bullet as it emerges from the block is (take, g = 10 m/s^2)

(a) 300 m/s (b) 220 m/s

(c) 150 m/s (d) 170 m/s

TS-EAMCET-10.09.2020, Shift-1

Ans. (d) : Given data –

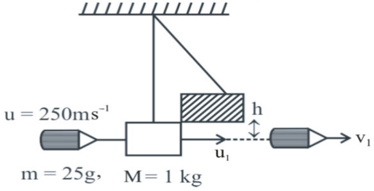
Mass of bullet (m) = 25g = 0.025 kg

Mass of block (M) = 1kg

Increase in height (h) = 20 cm = 0.2m

Velocity of block before collision (v) = 0 m/s

Velocity of bullet before collision (u) = 250 m/s



According to law of conservation of momentum –

Momentum before collision = momentum after collision

$$mu + Mv = mu_1 + Mv_1$$

$$0.025 \times 250 + 1\times0 = 0.025\times u_1 + 1\times v_1 \quad \text{...(i)}$$

Then, according to law of conservation of energy –

$$\frac{1}{2}mv_1^2 = mgh$$

$$\frac{1}{2}\times1\times v_1^2 = 1\times10\times0.2$$

$$v_1 = 2\text{ m/s}$$

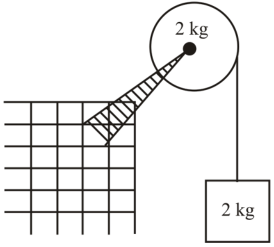
Putting the value of v_1 in equation (i), we get –

$$0.025 \times 250 + 1\times0 = 0.025 \times u_1 + 1 \times 2$$

$$6.25 - 2 = 0.025\,u_1$$

$$u_1 = \frac{4.25}{0.025} = 170\text{ m/s}$$

424. An object of mass 2 kg is hanging from a rope that is wrapped around a pulley of radius 25 cm. The mass of pulley is 2 kg. Find the acceleration of the object. (Assume, pulley to be a solid disk g = 10 m/s^2)



@apna_pdf

(a) $\frac{2}{3}\text{m/s}^2$ (b) $\frac{4}{3}\text{m/s}^2$

(c) $\frac{10}{3}\text{m/s}^2$ (d) $\frac{20}{3}\text{m/s}^2$

TS-EAMCET-10.09.2020, Shift-2

Ans. (d) : Given that, mass of object (m) = 2 kg

Radius of pulley (R) = 25 cm

Mass of pulley (M) = 2 kg

$g = 10 \text{ m/s}^2$

Let block falls through a height h,

From the law of conservation of energy,

$$\text{P.E} = \text{K.E}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\frac{MR^2}{2}\omega^2$$

$$\because \quad m = M = 2\text{kg}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 \qquad \left(\because \omega = \frac{v}{R}\right)$$

$$gh = \frac{v^2}{2} + \frac{v^2}{4}$$

$$gh = \frac{3v^2}{4}$$

$$gh = \frac{3}{4}R^2\omega^2 \qquad (\because v = R\omega)$$

Differentiating with respect to 't' on both side of the equation.

$$g\frac{dh}{dt} = \frac{3}{4}R^2 2\omega\frac{d\omega}{dt}$$

$$gv = \frac{3}{4}R^2 \times 2 \times \frac{v}{R}\alpha \qquad \left[\because \frac{d\omega}{dt} = \alpha\right]$$

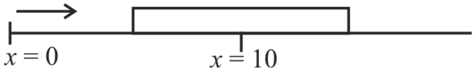
$$g = \frac{6}{4}\alpha \cdot R$$

$$\alpha \cdot R = \frac{4g}{6}$$

$$a_t = \frac{4g}{6} = \frac{4 \times 10}{6} \qquad [\because a_t = \alpha \cdot R]$$

Tangential acceleration of pulley $(a_t) = \frac{20}{3}\text{m/s}^2$

425. A bullet of mass 1 kg fired with speed 2ms^{-1} from x = 0 passes through a block of wood whose centre is kept at a distance of 10 m from the origin as shown in the figure. The retarding force F$_r$ on the bullet within the wooden block is –0.5/x. The minimum length of the block (upto one decimal digit) required to completely stop the bullet is (Assume, e^4 = 55)



(a) 10.1 m (b) 9.2 m

(c) 9.7 m (d) 19.3 m

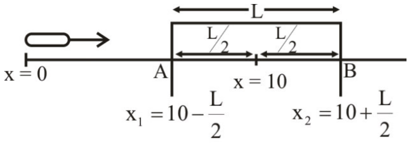
TS-EAMCET-03.05.2019, Shift-2

Ans. (d) : Given that,

Speed of bullet, $u = 2\text{ms}^{-1}$

Mass of bullet, m = 1 kg

$$F_r = \frac{-0.5}{x}$$



Work done, $dW = F_r\,dx$

$$\int dW = \int_{x_1}^{x_2} \frac{-0.5}{x}dx$$

$$W = \frac{-1}{2}\int_{x_1}^{x_2}\frac{1}{x}dx = \frac{-1}{2}\left[\log_e x\right]_{x_1}^{x_2}$$

$$W = \frac{-1}{2}\left[\log e\frac{x_2}{x_1}\right] \qquad \left[\because \log a - \log b = \log a/b\right]$$

So,

$$\Delta KE = \frac{1}{2}m[v^2 - u^2] \qquad (\because v = 0)$$

$$\Delta KE = \frac{-1}{2} \times 1 \times 2 \times 2$$

$$\Delta KE = -2\text{ J}$$

$\because \ \Delta KE = W = -2J$

From work - Energy theorem,

eqn (i) and (ii) becomes equal, we get

$$\therefore -2 = \frac{-1}{2}\log_e\left(\frac{x_2}{x_1}\right)$$

$$4 = \log_e\left(\frac{x_2}{x_1}\right)$$

$$e^4 = \frac{x_2}{x_1}$$

$$55x_1 = x_2 \qquad (\because e^4 = 55)$$

$$55 \times \left(10 - \frac{L}{2}\right) = \left(10 + \frac{L}{2}\right)$$

$$55 \times \left(\frac{20 - L}{2}\right) = \left(\frac{20 + L}{2}\right)$$

$$1100 - 55L = 20 + L$$

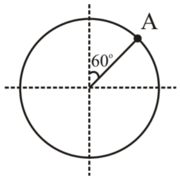
$$56L = 1080$$

$$L = \frac{1080}{56} = 19.29\text{ m}$$

$$L \approx 19.3\text{m}$$

426. A light rigid wire of length 1 m is attached to a ball A of mass 500 g to one end. The other end of the wire is fixed, so that the wire can rotate freely in the vertical plane about its fixed end. At the lowest point of the circular motion, the ball is given a horizontal velocity 6 m/s. Determined the radial component of the acceleration of the ball, when this rigid wire makes an angle 60^o with the upward vertical. (Take, g = 10 m/s^2)

@apna_pdf



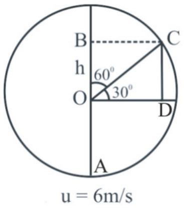
(a) $10\ m/s^2$ (b) $6\ m/s^2$
(c) $18\ m/s^2$ (d) $25\ m/s^2$

TS-EAMCET-04.05.2019, Shift-2

Ans. (b) : Given that,
Length of wire (l) = 1m

Mass of ball (m) = 500 g = $\frac{1}{2}$ kg

Velocity of ball at point (C) = 6 m/s



In Δ BOC,

$$\cos 60^\circ = \frac{OB}{OC}$$

$$h = \frac{1}{2}m$$

$$\therefore AB = AO + OB = l + h = 1 + \frac{1}{2}$$

$$AB = \frac{3}{2}\ m \qquad ....(i)$$

According to the law of conservation of energy (KE + PE) at a point A = (KE + PE) at point C

$$\frac{1}{2}mu^2 + 0 = \frac{1}{2}mv^2 + mg(AB)$$

$$u^2 = v^2 + 2g(AB)$$

$$\frac{u^2}{2} = \frac{v^2}{2} + g(AB)$$

$$\frac{(6)^2}{2} = \frac{v^2}{2} + 10 \times \frac{3}{2}$$

$$18 = \frac{v^2}{2} + 15$$

$$\frac{v^2}{2} = 3$$

$$v^2 = 6$$

Radial acceleration of ball

$$\frac{v^2}{l} = \frac{6}{1} = 6m/s^2$$

427. A circular ring of mass 10 kg rolls along a horizontal floor. The center of mass of the ring has a speed 1.5 m/s. The work required to stop the ring is

(a) 10 J (b) –6J
(c) 14.5 J (d) –22.5J

TS-EAMCET-04.05.2019, Shift-2

Ans. (d) : Given that,
Mass of circular ring (m) = 10 kg
Linear speed of ring (v) = $1.5\ ms^{-1}$

Total kinetic energy of rolling ring

$$(K.E.)_i = (K.E.)_{rotational} + (K.E.)_{linear}$$

$$= \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 \qquad \left[\begin{array}{l} I = mR^2 \\ \text{and } \omega = \dfrac{v}{R} \end{array}\right]$$

$$= \frac{1}{2}mR^2\left(\frac{v}{R}\right)^2 + \frac{1}{2}mv^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 = mv^2$$

$$= 10 \times (1.5)^2 = 22.5\ J$$

From work energy theorem, work required to stop the ring.

W = Change in kinetic energy

$$W = (K.E.)_f - (K.E.)_i = 0 - 22.5 = -22.5\ J$$

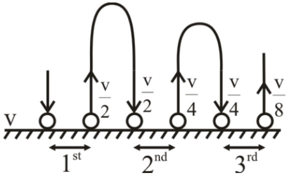
428. A bouncing ball of mass 200 g falls from the height of 5 m on a horizontal ground. After every impact with the ground, the velocity of the ball decreases by $\frac{1}{2}$ times.

The total momentum, the ball imparts on to the ground after 3 impacts is
(let g = 10 m/s^2)

(a) $\frac{14}{4}$kg m/s (b) $\frac{20}{6}$kg m/s
(c) $\frac{26}{12}$kg m/s (d) $\frac{21}{4}$kg m/s

TS-EAMCET-06.05.2019, Shift-1

Ans. (d) : Given,
Mass of ball (m) = 200g = 0.2kg
Height of ball (h) = 5m



From the third law of motion–

$$v^2 = u^2 + 2gh \qquad [\text{Initial velocity (u)} = 0]$$

So, velocity of ball at the first impact,

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 5} = 10m/s$$

For first impact
Momentum imparted = Change in momentum of ball

$$\Delta p_1 = mv - \left(-\frac{mv}{2}\right) = mv + m\frac{v}{2} = \frac{3}{2}mv$$

Second impact

$$\Delta p_2 = m\frac{v}{2} - \left(-m\frac{v}{4}\right) = m\frac{v}{2} + \frac{mv}{4} = \frac{3}{4}mv$$

Third impact

$$\Delta p_3 = m\frac{v}{4} - \left(-m\frac{v}{8}\right) = m\frac{v}{4} + \frac{mv}{8} = \frac{3}{8}mv$$

@apna_pdf

Total momentum imparted $(\Delta p_T) = \Delta p_1 + \Delta p_2 + \Delta p_3$

$$\Delta p_T = 3mv\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\right) = \frac{21}{8}mv$$

$$\Delta p_T = \frac{21}{8}\times 0.2\times 10$$

$$\Delta p_T = \frac{21}{4}\text{kg m/s}$$

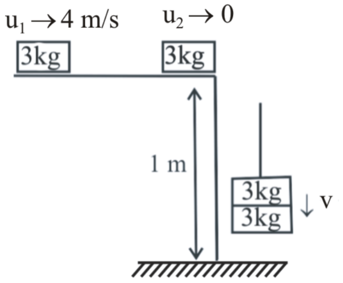
429. A box of mass 3 kg moves on a horizontal frictionless table and collides with another box of mass 3 kg initially at rest on the edge of the table at height 1 m. The speed of the moving box just before the collision is 4 m/s. The two boxes stick together and fall from the table. The kinetic energy just before the boxes strike the floor is (Assume, acceleration due to gravity, g = 10 m/s^2)

(a) 40 J (b) 80 J

(c) 96 J (d) 72 J

TS-EAMCET-03.05.2019, Shift-1

Ans. (d) : Given, $m_1 = m_2 = 3$kg, $h = 1$ m, $u_1 = 4$ m/s and $u_2 = 0$



According to law of conservation of momentum–

Total momentum before collision = Total momentum after collision

$m_1u_1 + m_2u_2 = (m_1 + m_2)v$

$3\times 4 + 3\times 0 = (3 + 3)$ v

$v = \frac{12}{6}$ m/s

v = 2 m/s

From the law of conservation of energy at 1m height and the bottom of the table –

$(K.E.)_1 + (P.E.)_1 = (K.E.)_2 + (P.E.)_2$

At the bottom just above the ground, the total energy is K.E. as height is approximately equals to zero [i.e. $(P.E.)_2 = 0$].

Therefore, $(K.E.)_2 = \frac{1}{2}(m_1 + m_2)v^2 + (m_1 + m_2)\,gh$

$(K.E.)_2 = \frac{1}{2}\times 6\times 4 + 6\times 10\times 1$

$= 12 + 60$

$= 72$ J

So, the kinetic energy just before the boxes strike the floor is 72 J.

430. A ball of mass m is thrown upwards with a velocity v. If air exerts an average resisting force F, the velocity with which the ball returns to thrower is

(a) $v\sqrt{\frac{mg}{mg+F}}$ (b) $v\sqrt{\frac{F}{mg+F}}$

(c) $v\sqrt{\frac{mg+F}{mg}}$ (d) $v\sqrt{\frac{mg-F}{mg+F}}$

CG PET 2019

Ans. (d) : Given that,

Mass = m

Velocity = v

Air resisting Force = F

For upward motion,

Net force = mg + F

Retardation (a) = $\frac{mg+F}{m}$

Distance $(s) = \frac{v^2}{2a} = \frac{v^2m}{2(mg+F)}$ ....(i)

For downward motion,

Net force = mg – F

Acceleration$(a_1) = \frac{mg-F}{m}$

Distance $(s_1) = \frac{v_1^2}{2a_1} = \frac{v_1^2m}{2(mg-F)}$ .....(ii)

$s = s_1$

Putting the value from equation (i) and (ii), we get –

$$\frac{v^2m}{2(mg+F)} = \frac{v_1^2m}{2(mg-F)}$$

$$v_1 = v\sqrt{\frac{(mg-F)}{(mg+F)}}$$

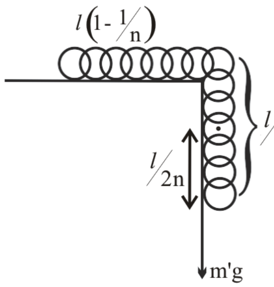
431. A uniform chain of mass m and length *l* is on a smooth horizontal table with $\left(\frac{1}{n}\right)^{th}$ part of its length is hanging from one end of the table. The velocity of the chain, when it completely slips off the table is

(a) $\sqrt{gl\left(1-\frac{1}{n^2}\right)}$ (b) $\sqrt{2gl\left(1+\frac{1}{n^2}\right)}$

(c) $\sqrt{2gl\left(1-\frac{1}{n^2}\right)}$ (d) $\sqrt{2gl}$

AP EAMCET (22.04.2018) Shift-II

Ans. (a) : Given that, total length of chain = *l*, mass of chain = m, mass of the hanging chain (m') = $\frac{m}{n}$



@apna_pdf

At surface of table, Potential energy (PE) = 0

Potential energy of chain with $\frac{1}{n}^{\text{th}}$ part hanging

$$(\text{P.E.})_1 = m'gh = \frac{m}{n}g\times\frac{l}{2n} = \frac{mgl}{2n^2}$$

Potential energy of chain when it leaves the table

$$(\text{P.E.})_2 = \frac{mgl}{2}$$

Hence, (K.E.) = ΔP.E.

$$= (\text{P.E.})_2 - (\text{P.E.})_1$$

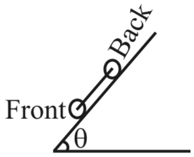
$$\frac{1}{2}mv^2 = \frac{mgl}{2} - \frac{mgl}{2n^2}$$

$$mv^2 = mgl - \frac{mgl}{n^2}$$

$$v^2 = gl\left[1-\frac{1}{n^2}\right]$$

$$v = \sqrt{gl\left(1-\frac{1}{n^2}\right)}$$

432. The front solid cylinder has mass $\frac{M}{3}$ while the back one solid cylinder has mass $\frac{2M}{3}$. The centre's of these cylinders are connected by massless rod as shown. Both the cylinders have same radii R. The system is released from rest on the inclined plane. The cylinders roll down. The speed of the rod after system descending a vertical distance h is

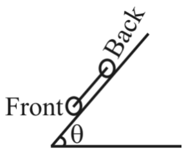


(a) $\sqrt{\frac{2gh}{3}}$ (b) $\sqrt{2gh}$

(c) $\sqrt{\frac{4gh}{3}}$ (d) $\sqrt{\frac{3gh}{7}}$

UPSEE - 2018

Ans. (c) : Given, $M_1 = \frac{M}{3}$, $M_2 = \frac{2M}{3}$



According to conservation of energy–

Loss of potential energy = Gain of kinetic energy

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

$$M_1gh + M_2gh = \frac{1}{2}(M_1+M_2)v^2 + \frac{1}{2}(I_1+I_2)\omega^2$$

$$(M_1+M_2)gh = \frac{1}{2}(M_1+M_2)v^2 + \frac{1}{2}\left(\frac{1}{2}M_1R^2+\frac{1}{2}M_2R^2\right)\frac{v^2}{R^2}$$

$$\left[\because I = \frac{1}{2}MR^2, \omega = \frac{v}{R}\right]$$

$$\left(\frac{M}{3}+\frac{2M}{3}\right)gh = \frac{1}{2}\left(\frac{M}{3}+\frac{2M}{3}\right)v^2 + \frac{1}{4}\left(\frac{M}{3}R^2+\frac{2M}{3}R^2\right)\frac{v^2}{R^2}$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{4}Mv^2$$

$$Mgh = \frac{3}{4}Mv^2$$

$$gh = \frac{3}{4}v^2$$

$$v^2 = \frac{4gh}{3} = \sqrt{\frac{4gh}{3}}$$

433. Suppose a particle of mass m moving with potential energy $U = \frac{kx^2}{2} + Ae^{-\alpha x^2}$ has velocity v_a when its position is x = a. Here, k, A and α are constants. The particle will be able to pass the origin, if

(a) $A \ge \frac{mv_a^2+ka^2}{2\left(1-e^{-ax^2}\right)}$ (b) $A \le \frac{mv_a^2+ka^2}{2\left(1-e^{-\alpha a^2}\right)}$

(c) $A \le \frac{mv_a^2+ka^2}{\left(1-e^{-ax^2}\right)}$ (d) $A \ge \frac{mv_a^2+ka^2}{\left(1-e^{-\alpha a^2}\right)}$

UPSEE - 2018

Ans. (b) : Here the potential energy (U) is a function of position (x) and given as,

$$U(x) = \frac{kx^2}{2} + Ae^{-\alpha x^2}$$

According to law of conservation of energy, the total energy at initial point is always equal to the total energy at final position of the particle.

Now, at x = 0

$$\text{Total energy}_{(x=0)} = \text{Total energy}_{(x=a)}$$

$$\text{P.E.}_{(x=0)} + \text{K.E.}_{(x=0)} = \text{P.E.}_{(x=a)} + \text{K.E.}_{(x=a)}$$

$$\frac{k(0)^2}{2} + Ae^{-\alpha\times 0^2} + \text{K.E.}_{(x=0)} = \frac{ka^2}{2} + Ae^{-\alpha a^2} + \frac{1}{2}mv_a^2$$

$$A + \text{K.E.}_{(x=0)} = \frac{ka^2}{2} + Ae^{-\alpha a^2} + \frac{1}{2}mv_a^2$$

Therefore, $\text{K.E.}_{(x=0)}$ is unknown, A < RHS, and if $\text{K.E.}_{(x=0)} = 0$, A = RHS

So, $$A \le \frac{ka^2}{2} + Ae^{-\alpha a^2} + \frac{1}{2}mv_a^2$$

$$A\left(1-e^{-\alpha a^2}\right) \le \frac{ka^2+mv_a^2}{2}$$

$$A \le \frac{ka^2+mv_a^2}{2\left(1-e^{-\alpha a^2}\right)}$$

@apna_pdf

434. Some of the following equations are kinetic equations, where the symbols have their usual meaning. The work-energy theorem is represented by

(a) $v = u + at$ (b) $s = ut$

(c) $s = ut + \frac{1}{2}at^2$ (d) $v^2 = \frac{u^2}{2} + as$

(e) $v^2 = u^2 + 2as$

Kerala CEE -2018

Ans. (e) : Let,

v = Final velocity
u = Initial velocity
a = Constant acceleration
s = Displacement

According to work-energy theorem–

Net work done = Change in kinetic energy

$$W = K.E_{final} - K.E_{initial}$$

So, $$F.s = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \qquad (\because W = F.s)$$

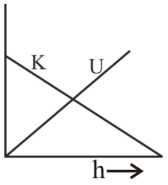
$$ma.s = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \qquad (F = ma)$$

$$v^2 - u^2 = 2as$$

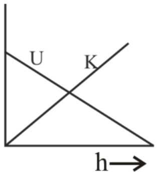
$$v^2 = u^2 + 2as$$

435. Which of the following graphs represent kinetic energy (K), potential energy (U) and height (h) from the ground for a freely falling body?

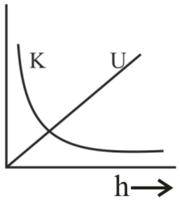
(a)



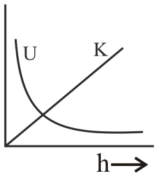
(b)



(c)



(d)



CG PET- 2017

Ans. (a) : We know if body is falling freely then total mechanical energy is constant.

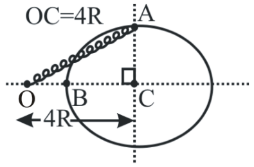
According to law of conservation of energy

P.E. + K.E. = Constant

Potential energy increases and kinetic energy decreases when the height of the particle increases.

So, Graph (A) represents kinetic energy (K), potential energy (U) and height (h) from the ground for a freely falling body.

436. A bead of mass m can slide without friction on a fixed circular horizontal ring of radius 3R having centre at the point C. The bead is attached to one of the ends of spring of spring constant k. Natural length of spring is R and the other end of the spring is fixed at point O as shown in figure. Bead is released from position A, what will be kinetic energy of the bead when it reaches at point B?

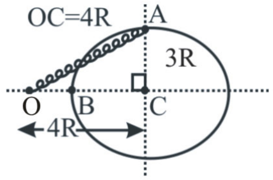


(a) $\frac{25}{2}kR^2$ (b) $\frac{9}{2}kR^2$

(c) $8kR^2$ (d) $12kR^2$

UPSEE - 2017

Ans. (c) : Given that, mass of bead = m, radius of circular horizontal ring = 3R, natural length of spring = R



Applying concept of the conservation law of energy,

$$K.E_{initial} + P.E_{initial} = K.E_{final} + P.E_{final}$$

$$0 + \frac{1}{2}k(OA - R)^2 = K.E_{final} + \frac{1}{2}k[OB - R]^2$$

$$\frac{1}{2}k[5R - R]^2 = K.E_{final} + \frac{1}{2}k[R - R]^2$$

$$K.E_{final} = 8kR^2$$

437. The work-energy theorem states that the change in

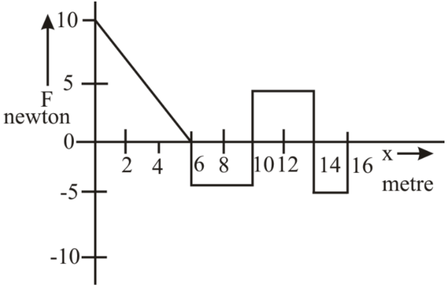
(a) Kinetic energy of a particle is equal to the work done on it by the net force
(b) Kinetic energy of a particle is equal to the work done by one of forces acting on it
(c) Potential energy of a particle is equal to the work done on it by the net force
(d) Potential energy of a particle is equal to the work done by one of the forces acting on it
(e) Total energy of a particle is equal to the work done on it by the net force

Kerala CEE - 2016

Ans. (a) : The work-energy theorem states that the net work done by the forces on an object is equal to the change in its kinetic energy.

Thus, $$W = \Delta K.E. = \frac{1}{2}mv^2$$

438. A particle is acted upon by a force F which varies with position x as shown in figure. If the particle at x = 0 has kinetic energy of 25 J, then the kinetic energy of the particle at x = 16 m is

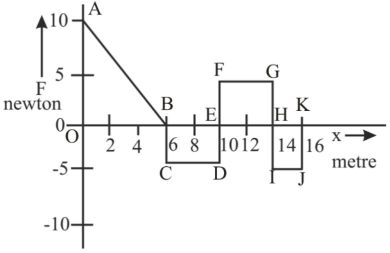


@apna_pdf

(a) 45 J (b) 30 J
(c) 70 J (d) 135 J
(e) 20 J

Kerala CEE - 2009

Ans. (a) : Given that, $(K.E.)_i = 25$ J



Work done = Area under (F – x) graph–

W = Area of (ΔOAB) + Area of (□BCDE) + Area of (□EFGH) + Area of (□HIJK)

$$W = \frac{1}{2}\times 6\times 10 - 5\times 4 + 5\times 4 - 5\times 2$$

W = 20 J

According to work-energy theorem–

Work done = $K_{final} - K_{initial}$

$W = (K_f)_{x=16m} - (K_i)_{x=0m}$

$(K_f)_{x=16m} = (K_i)_{x=0m} + W$

$= 25\text{ J} + 20\text{ J}$

$(K_f)_{x=16m} = 45$ J

439. A 3 kg object has initial velocity $\left(6\hat{i}-2\hat{j}\right)$ m/s. The total work done on the object if its velocity changes to $\left(8\hat{i}+4\hat{j}\right)$ m/s is

(a) 216 J (b) 44 J
(c) 60 J (d) 120 J

UPSEE - 2016

Ans. (c) : Given, mass (m) = 3 kg

As, Kinetic energy (K.E) = $\frac{1}{2}mv^2$

Net velocity $\left(v^2\right) = v_x^2 + v_y^2$

$v_i^2 = (36+4)$

$v_i^2 = 40$

And final velocity $\left(v_f\right)^2 = 8^2 + 4^2$

$(v_f)^2 = 64 + 16$

$v_f^2 = 80$

By the work energy theorem, the net work done by the object is equal to the change in the kinetic energy of the object.

$W_{net} = \Delta K.E.$

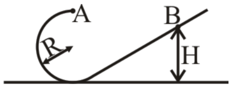
$$W_{net} = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

$$W_{net} = \frac{1}{2}\times 3\,(80-40)$$

$$W_{net} = \frac{3}{2}\times 40$$

$W_{net} = 60$ J

440. A small bead of mass m slides on a smooth wire that is bent in a circle of radius R. It is released at the top of the circular part of the wire (point A in the figure) with a negligibly small velocity. Find the height H where the bead will reverse direction.

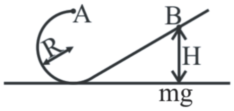


(a) R (b) 2R
(c) $\frac{3R}{2}$ (d) $\frac{5R}{2}$

UPSEE - 2016

Ans. (b) : Given that, mass of bead = m, circle of radius = R

Apply conservation of energy at two different position of the given object.



Energy conservation between points A and B –

$(P.E.)_A + (K.E.)_A = (P.E.)_B + (K.E.)_B$

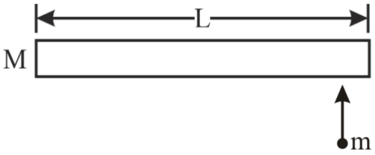
$$mg\,(2R) + \frac{1}{2}m\,(0)^2 = mgH + \frac{1}{2}m(0)^2$$

mg(2R) = mgH

2R = H

H = 2R

441. A stick of length L and mass M lies on a frictionless horizontal surface on which it is free to move in any way. A ball of mass m moving with speed v collides elastically with the stick as shown in figure.



If after the collision the ball comes to rest, then what should be the mass of the ball?

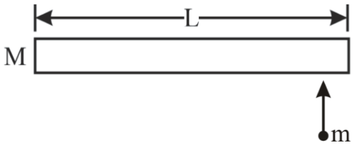
(a) m = 2M (b) m = M
(c) m = M/2 (d) m = M/4

UPSEE - 2013

Ans. (d) : Given that,

Length of stick = L

Mass of stick = M



According to law of conservation of linear momentum–

mv = MV

$$V = \frac{mv}{M}$$

@apna_pdf

According to law of conservation of angular momentum–

$$mv\left(\frac{L}{2}\right)=\left(\frac{ML^2}{12}\right)\omega$$

$$\omega=\frac{6mv}{ML}$$

As the collision is elastic, we get-

$$\frac{1}{2}mv^2=\frac{1}{2}MV^2+\frac{1}{2}I\omega^2$$

$$\frac{1}{2}mv^2=\frac{1}{2}M\left(\frac{mv}{M}\right)^2+\frac{1}{2}\left(\frac{ML^2}{12}\right)\left(\frac{6mv}{ML}\right)^2$$

$$m=\frac{m^2}{M}+\frac{3m^2}{M}$$

$$m=m^2\left(\frac{1}{M}+\frac{3}{M}\right)$$

$$1=m\left(\frac{4}{M}\right)$$

$$m=\frac{M}{4}$$

442. Power supplied to a particle of mass 2 kg varies with time as P = $\frac{t^2}{2}$ watt, where t is in second, If the velocity of particle at t = 0 is v = 0, the velocity of particle at time t = 2 s will be

(a) 1 m/s (b) 4 m/s

(c) $2\sqrt{2}$ m/s (d) $2\sqrt{\frac{1}{3}}$ m/s

UPSEE - 2013

Ans. (d) : Given that, mass of particle = 2 kg

$$P=\frac{t^2}{2}\text{ watt}$$

Where, t is denoted in sec

Velocity of particle at t = 0 is v = 0

The velocity of particle at time (t) = 2 s

To applying work energy theorem

Work done = Change in kinetic energy

$$\int P\,dt=K_{\text{final}}-K_{\text{initial}}$$

$$\int_0^2\left(\frac{t^2}{2}\right)dt=\frac{1}{2}mv^2-0$$

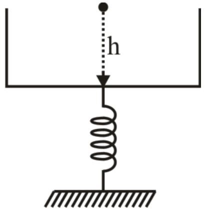
$$\frac{1}{2}\left[\frac{t^3}{3}\right]_0^2=\frac{1}{2}(2)v^2$$

$$\frac{1}{2}\times\frac{8}{3}=v^2$$

$$v=2\sqrt{\frac{1}{3}}\text{ m/s}$$

443. A massless platform is kept on a light elastic spring as shown in figure. When a sand particle of mass 0.1 kg is dropped on the pan from a height of 0.24 m, the particle strikes the pan and spring is compressed by 0.01 m.

From what height should the particle be dropped to cause a compression of 0.04 m.



(a) 3.96 m (b) 0.396 m

(c) 4 m (d) 0.4 m

BITSAT-2011

Ans. (a) : Given, mass of particle = 0.1 kg, particle is dropped from height = 0.24 m

compressed length = x = 0.01 m

Spring length = h = 0.24 m

since,

$\because$ or P.E. = mgh and K.E. = $\frac{1}{2}mv^2$

From conservation of energy

$$mg(h+x)=\frac{1}{2}kx^2$$

$$mg(0.24+0.01)=\frac{1}{2}k(0.01)^2 \quad .....(i)$$

Let, the particle dropped from height H to compress the pan of 0.04 m

Then, $$mg\,(H+0.04)=\frac{1}{2}k(0.04)^2 \quad ......(ii)$$

Dividing equation (ii) from (i), we get–

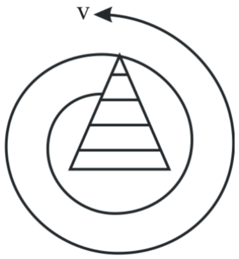
$$\frac{H+0.04}{0.24+0.01}=\frac{16}{1}$$

H + 0.04 = 16 × 0.25

H + 0.04 = 4

H = 3.96 m

444. A cable in the form of a spiral roll (shown in the figure) has a linear density ρ. It is uncoiled at a uniform speed v, if the total length of the cable is L. The work done in uncoiling the cable is



(a) $\rho Lv^2/4$ (b) $\rho Lv^2/2$

(c) $\rho Lv^2/3$ (d) ρLv^2

JCECE-2015

@apna_pdf

Ans. (b) : Given that,

Initial speed of the coil (u) = 0 m/s

Linear density = ρ

Final speed = v (uncoiling speed)

Length of the cable = L

Mass of coil = ρL

So,

Work done, W = ΔKE = $K_f - K_i$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$W = \frac{1}{2}mv^2 - 0$$

$$W = \frac{1}{2}\times(\rho L)(v)^2$$

$$W = \frac{1}{2}\rho L v^2$$

445. A child is swinging a swing. Minimum and maximum heights of swing from earth's surface are 0.75 m and 2m respectively. The maximum velocity of this swing is:

(a) 5 m/s (b) 10 m/s

(c) 15 m/s (d) 20 m/s

JCECE-2004

Ans. (a) : Given that,

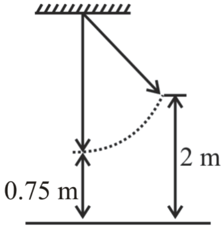
Minimum height of swing from the earth's surface,

$H_1 = 0.75$m

Maximum height of swing from earth's surface,

$H_2 = 2$m

From energy conservation rule,



Kinetic energy = Potential energy

$$\frac{1}{2}mv_{max}^2 = mg(H_2 - H_1)$$

$$\frac{1}{2}mv_{max}^2 = mg(2 - 0.75)$$

$$v_{max} = \sqrt{2\times10\times1.25}$$

$$v_{max} = \sqrt{25}$$

v_{max} = 5 m/s

446. Two bodies of masses 0.1 kg and 0.4 kg move towards each other with the velocities 1 m/s and 0.1 m/s respectively. After collision they stick together. In 10 sec the combined mass travels:

(a) 120 m (b) 0.12 m

(c) 12 m (d) 1.2 m

AIIMS-2010

Ans. (d) : Given that,

Mass of first body (m_1) = 0.1 kg

Mass of second body (m_2) = 0.4 kg

Velocity before collision (v_1) = 1 m/s

Velocity before collision moving opposite direction (v_2) = – 0.1 m/s

t = 10 s

According to conservation of linear momentum,

$$m_1v_1 + m_2v_2 = (m_1+m_2)v$$

$$(0.1)(1) + (0.4)(-0.1) = (0.1+0.4)v$$

$$0.1 - 0.04 = 0.5\ v$$

$$v = 0.12 m/s$$

∴ Distance, s = vt

$$s = 0.12\times10 = 1.2m$$

447. If the escape speed of a projectile on Earth's surface is 11.2 kms^{-1} and a body is projected out with thrice this speed, then determine the speed of the body far away from the Earth.

(a) 56.63 kms^{-1} (b) 33 kms^{-1}

(c) 39 kms^{-1} (d) 31.7 kms^{-1}

BCECE-2015

Ans. (d) : Given,

Escape velocity (v_e) = 11.2 kms^{-1}

Projected speed (v_p) = $3v_e$

Mass of projectile = m

Suppose energy of projectile far away from the earth = v_1

$$\text{Total energy} = \frac{1}{2}mv_p^2 - \frac{1}{2}mv_e^2$$

Total Energy of the projectile far away from the earth

$$= \frac{1}{2}mv_1^2 \qquad \text{(At infinite, P.E. = 0)}$$

Applying law of conservation of energy,

$$\frac{1}{2}mv_p^2 - \frac{1}{2}mv_e^2 = \frac{1}{2}mv_1^2$$

$$v_1 = \sqrt{v_p^2 - v_e^2}$$

$$v_1 = \sqrt{(3v_e)^2 - (v_e)^2}$$

$$v_1 = \sqrt{8}\,v_e$$

$$v_1 = \sqrt{8}\times11.2$$

v_1 = 31.6736 km/s

v_1 □ 31.7 kms^{-1}

Speed of the body at for away from the earth is

= 31.7 kms^{-1}

448. A spring of constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5cm is–

(a) 6.25 Nm (b) 12.5 Nm

(c) 18.75 Nm (d) 25.00 Nm

BCECE-2011

@apna_pdf

Ans. (c) : Given that,

Spring constant (k) = 5×10^3 N/m

$x_1 = 5$ cm = 0.05m, $x_2 = x_1 + 5$ cm

$x_2 = 10$ cm = 0.1 m

We know that, W = ΔPE

$W = PE_2 - PE_1$

Now, $PE_1 = \frac{1}{2}kx_1^2$

$$PE_1 = \frac{1}{2}\times5\times10^3\ (0.05)^2 = 6.25J$$

$$PE_2 = \frac{1}{2}kx_2^2$$

$$PE_2 = \frac{1}{2}\times 5\times 10^3\ (0.1)^2 = 25J$$

$W = PE_2 - PE_1 = 25 - 6.25 = 18.75J$

449. 4m^3 of water is to be pumped to a height of 20m and forced into a reservoir at a pressure of 2×10^5 N/m^2. The work done by the motor is (external pressure = 10^5 N/m^2)

(a) 8×10^5J (b) 16×10^5J

(c) 12×10^5J (d) 32×10^5J

BCECE-2008

Ans. (c) : Given that,

Volume of pumped water (v) = 4m^3

Density of water (ρ) = 1×10^3 kg/m^3

Gravitational acceleration (g) = 10 m/s^2,

Height of pumped water (h) = 20 m

Here, $\Delta p = (2\times10^5 - 1\times10^5)$ N/m^2 = 1×10^5 N/m^2

Work done = Change in gravitational potential energy + Work done against external pressure

$W = mgh + \Delta p\ v$

$W = v\rho gh + \Delta p\ v$

$\therefore$ $W = 4 \times 1\times10^3 \times 10\times20 + 1\times 10^5 \times 4$

$W = 8 \times 10^5 + 4 \times 10^5$

$W = 12 \times 10^5$ J

450. A meter stick is held vertically with one end on the floor and is then allowed to fall. Assuming that the end on the floor the stick does not slip, the velocity of the other end when it hits the floor, will be–

(a) 10.8 m/s (b) 5.4 m/s

(c) 2.5 m/s (d) none of these

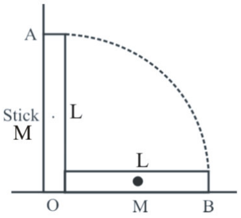
BCECE-2007

Ans. (b) : Let,

Height of the meter stick = L

Mass = M

Center of mass meter stick fall from height = $\frac{1}{2}$L



According to law of conservation of energy

$$Mg\frac{1}{2}L = \frac{1}{2}I\omega^2 \qquad ...(i)$$

Where, $I = \frac{1}{3}ML^2$, and ω =Angular velocity

From the equation (i),

$$Mg\frac{L}{2} = \frac{1}{2}\times\frac{ML^2}{3}\omega^2$$

$$Mg\frac{L}{2} = \frac{ML^2}{6}\omega^2$$

$$\omega = \sqrt{\frac{3g}{L}}$$

Speed of other end, v = ωL

$v = \omega = \sqrt{3g/L}$ [Where L = 1m]

$v = \sqrt{3g}$

$v = \sqrt{3\times9.8}$

$v = \sqrt{29.4} = 5.4$m/s

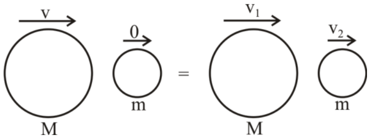
451. A body of mass M moves with velocity v and collides elastically with another body of mass m (M>>m) at rest, then the velocity of body of mass m is :

(a) v (b) 2v

(c) v/2 (d) zero

BCECE-2004

Ans. (b) :



Applying conservation of momentum-

$p_i = p_f$

$Mv + m\times0 = Mv_1 + mv_2$

$Mv = Mv_1 + mv_2$ ….(i)

As given the collision is elastic, e = 1

$$e = 1 = \left(\frac{v_2 - v_1}{u_1 - u_2}\right)$$

$$1 = \left(\frac{v_2 - v_1}{v - 0}\right)$$

$\Rightarrow v_2 - v_1 = v$

$\Rightarrow v_1 = v_2 - v$ ….(ii)

On putting the value of equation (ii) in equation (i), we get

$Mv = M(v_2-v) + mv_2$

$Mv = Mv_2 - Mv + mv_2$

$2Mv = (M + m)v_2$

$$v_2 = \frac{2Mv}{M+m}$$

According to question M >>> m

So, $M + m \approx M$

$$\therefore\ v_2 = \frac{2Mv}{M} = 2v$$

@apna_pdf

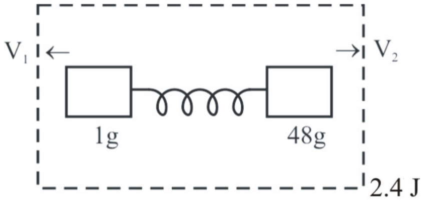
452. A spring is held compressed so that its stored energy is 2.4J. Its ends are in contact with masses 1g and 48g placed on a frictionless table. When the spring is released, the heavier mass will acquire a speed of–

(a) $\frac{2.4}{49}\text{ms}^{-1}$ (b) $\frac{2.4\times48}{49}\text{ms}^{-1}$

(c) $\frac{10^3}{7}\text{cms}^{-1}$ (d) $\frac{10^6}{7}\text{cms}^{-1}$

BCECE-2010

Ans. (c) : Given, $m_1 = 1\text{g}$, $m_2 = 48\text{g}$



Conservation of momentum,

Now, $m_1v_1 = m_2v_2$

$$1\times v_1 = 48\times v_2$$

$$v_1 = 48v_2$$

According to law of conservation of energy,

$$PE = KE_1 + KE_2$$

$$2.4 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$2.4 = \frac{1}{2}\times1\times10^{-3}\times v_1^2 + \frac{1}{2}\times48\times10^{-3}\times v_2^2$$

$$2.4 = \frac{1}{2}\times10^{-3}\left[48^2v_2^2 + 48v_2^2\right]$$

$$4.8\times10^{+3} = 48v_2^2[49]$$

$$v_2^2 = \frac{100}{49}$$

$$v_2 = \frac{10}{7}\text{m/s}$$

$$v_2 = \frac{10^3}{7}\text{cms}^{-1}$$

453. A body of mass 2 kg moving with velocity of 6m/s strikes in elastically with another body of same mass at rest. The amount of heat evolved during collision is

(a) 18J (b) 36J

(c) 9J (d) 3J

VITEEE-2013

Ans. (a) : Given that, mass (m) = 2kg, velocity (v_1) = 6m/s, $v_2 = 0$

Common velocity, $v = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$

$$= \frac{2\times6 + 2\times0}{2+2} = 3\text{ m/s}$$

Initial kinetic energy,

$$E_1 = \frac{1}{2}mv_1^2 = \frac{1}{2}\times2\times6^2 = 36\text{J}$$

Final kinetic energy,

$$E_2 = \frac{1}{2}(m_1 + m_2)v^2$$

$$E_2 = \frac{1}{2}(2+2)3^2$$

$$= \frac{1}{2}(4)\times9 = 2\times9 = 18\text{J}$$

So,

The amount of heat evolved = $E_1 - E_2$

= 36 – 18 = 18J

454. A body of mass 5 m kg initially at rest explodes into 3 fragments with mass ratio 3:1:1. Two of fragments each of mass 'm' are found to move with a speed of 60 m/s is mutually perpendicular directions. The velocity of third fragment is

(a) $10\sqrt{2}$ (b) $20\sqrt{2}$

(c) $20\sqrt{3}$ (d) $60\sqrt{2}$

VITEEE-2013

Ans. (b) : Given,

Speed (v) = 60m/s

Velocity of third fragment = ?

Using principal of conservation of linear momentum,

$$3m\times v = \sqrt{(m\times60)^2 + (m\times60)^2}$$

$$3m\times v = \sqrt{(60m)^2\times2}$$

$$3m\times v = 60\text{ m}\times\sqrt{2}$$

$$v = \frac{60\sqrt{2}}{3}$$

$$v = 20\sqrt{2}\text{ m/s}$$

Hence, velocity of third fragment is $20\sqrt{2}\text{ m/s}$

455. A particle of mass 4 m explodes into three pieces of masses m, m and 2m. The equal masses move along X-axis and Y-axis with velocities 4 ms^{-1} and 6 ms^{-1} respectively. The magnitude of the velocity of the heavier mass is

(a) $\sqrt{17}\text{ms}^{-1}$ (b) $2\sqrt{13}\text{ms}^{-1}$

(c) $\sqrt{13}\text{ms}^{-1}$ (d) $\frac{\sqrt{13}}{2}\text{ms}^{-1}$

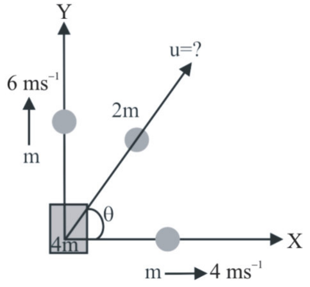
VITEEE-2009

Ans. (c) : Given,

$v_1 = 4\text{m/s}$

$v_2 = 6\text{m/s}$

Velocity of third fragment = ?



@apna_pdf

Using principal of conservation of linear momentum,

$$2m \times u = \sqrt{(m\times 4)^2 + (m\times 6)^2}$$

$$2m \times u = \sqrt{52}m$$

$$u = \sqrt{13}\, m/s$$

456. A body is tied to one end of the string and whirled in a vertical circle, the physical quantity which remains constant is

(a) momentum (b) speed

(c) kinetic energy (d) total energy

J&K CET- 2007

Ans. (d) : When a body with string, whirled in a circle vertically, then speed, momentum and kinetic energy change continuously. So the physical quantity which remains constant is the total energy.

457. If a body losses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate more before coming to rest?

(a) 1 cm (b) 2 cm

(c) 3 cm (d) 4 cm

AIEEE 2002

Ans. (a) : Let,

Initial velocity = u.

$\therefore$ Final velocity $v = \frac{u}{2}$

Displacement, s = 3 cm

Acceleration = –a

By the equation of motion

$$v^2 = u^2 + 2as$$

$$\left(\frac{u}{2}\right)^2 = u^2 - 2a(3)$$

$$\frac{u^2}{4} = u^2 - 6a$$

$$3u^2 = 24a$$

$$u^2 = 8a \quad \text{....(i)}$$

Let, it penetrate *l* cm before coming to rest

Initial velocity = $\frac{u}{2}$

Final velocity = 0

$$\therefore \quad v^2 = u^2 + 2as$$

$$0 = \left(\frac{u}{2}\right)^2 - 2al$$

$$0 = \frac{u^2}{4} - 2al$$

$$0 = u^2 - 8al$$

$$u^2 = 8al \quad \text{....(ii)}$$

From equation (i) and (ii)

$$8a = 8al$$

$$l = 1 \text{ cm}$$

458. An 80 kg man is riding on a small 40 kg cart at a speed of 4 m/s. He jumps off the cart with zero horizontal speed. What is the resulting changes in the speed of the cart (in m/s)?

(a) 4 (b) 8

(c) 12 (d) 0

AMU-2007

Ans. (b) : Given,

$m_1 = 80$ kg, $m_2 = 40$ kg, $v_1 = 4$ m/s

Applying the law of conservation of momentum to the system

Total initial momentum $(p_i) = (m_1 + m_2)v_1$

$$= (80+40)\times 4$$

$$= 480$$

Total final momentum $(p_f) = (80\times 0 + 40\times v) = 40v$

By law of conservation of momentum

$$p_i = p_f$$

$$480 = 40v$$

$$v = \frac{480}{40} = 12 m/sec$$

The resulting changes in the speed of the cart = 12 – 4

= 8 m/sec

459. Two bodies with kinetic energies in the ratio 4:1 are moving with equal linear momentum. The ratio of their masses is

(a) 1:2 (b) 1:1

(c) 4:1 (d) 1:4

AIPMT- 1999

Ans. (d) : Given that,

$$\frac{(K.E.)_1}{(K.E.)_2} = \frac{4}{1}$$

We know that–

$$(K.E.)_1 = \frac{p^2}{2m_1} \qquad (\because p_1 = p_2 = p) \quad \text{......(i)}$$

$$(K.E.)_2 = \frac{p^2}{2m_2} \quad \text{......(ii)}$$

From equation (i) and (ii)

$$\frac{(K.E.)_1}{(K.E.)_2} = \frac{p^2}{2m_1} \times \frac{2m_2}{p^2}$$

$$\frac{(K.E.)_1}{(K.E.)_2} = \frac{m_2}{m_1}$$

$$\frac{4}{1} = \frac{m_2}{m_1}$$

$$\therefore \frac{m_1}{m_2} = \frac{1}{4}$$

$$m_1 : m_2 = 1:4$$

460. A body of mass 1 kg is thrown upwards with a velocity 20 ms^{-1}. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction? (Take g = 10ms^{-2})

(a) 20 J (b) 30 J

(c) 40 J (d) 10 J

AIPMT- 2009

@apna_pdf

Ans. (a) : Given,

Height (h) = 18 m

$\text{Velocity}(v) = 20\,\text{m/sec}$

$\text{Mass}(m) = 1\text{kg}$

$\text{Acceleration due to gravity } (g) = 10\text{m/sec}^2$

The energy lost due to the air friction will be equal to the difference in the initial kinetic energy and the final potential energy

$\therefore$ Loss of energy = K.E. – P.E.

$$= \frac{1}{2}mv^2 - mgh$$

$$= \frac{1}{2}\times 1\times(20)^2 - 1\times 10\times 18$$

$$= \frac{1}{2}\times 1\times 400 - 180$$

$$= 200 - 180 = 20\text{ J}$$

461. When a body is thrown vertically upwards with a velocity of 50 m/s, the percentage of its initial kinetic energy converted into potential energy after 4 seconds is:
($g = 10\text{ ms}^{-2}$)

(a) 96%	(b) 50%
(c) 24%	(d) 4%

AP EAMCET(Medical)-2001

Ans. (a) : Given that,

Velocity (u) = 50 m /sec

Time (t) = 4 sec

Acceleration due to gravity (g) =10 m/s^2

From the first law of motion under the gravity–

$v = u - gt$

$v = 50 - 10 \times 4$

$v = 50 - 40$

$v = 10$ m/s

$$(\text{K.E.})_f = \frac{1}{2}mv^2$$

$$= \frac{1}{2}m(10)^2 = 50\text{ m}$$

$$(\text{K.E.})_i = \frac{1}{2}mu^2$$

$$= \frac{1}{2}m(50)^2 = 1250\text{ m}$$

After 4 s of throwing vertically

Potential energy = change in kinetic energy

P.E = 1250m – 50m

= 1200m

$$\%\text{ of converted energy} = \frac{\text{P.E}}{(\text{K.E})_i}\times 100$$

$$= \frac{1200\text{m}}{1250\text{m}}\times 100 = 96\%$$

462. A steel ball of mass 0.1kg falls freely from a height of 10m and bounces to a height of 5.4m from the ground. If the dissipated energy in this process is absorbed by the ball, the rise in its temperature is:
(The specific heat of steel is 460 J/kg°C)

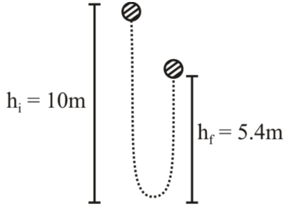
(a) 0.01°C	(b) 0.1°C
(c) 1°C	(d) 1.1°C

AP EAMCET(Medical)-2000

Ans. (b) : Given that,

$m = 0.1$ kg $\quad h_i = 10$ m $\quad h_f = 5.4$ m

$s = 460$ J/kg^{o}C



Loss in potential energy = $(PE)_i - (PE)_f$

$= mgh_i - mgh_f$

$= mg(h_i - h_f)$

$= 0.1 \times 10(10 - 5.4)$

$= 4.6$ J

Heat (Q) = $ms\Delta T$

$= 0.1 \times 460 \times \Delta T$

Loss in PE = Q

$4.6 = 0.1 \times 460 \times \Delta T$

$$\frac{4.6}{0.1\times 460} = \Delta T$$

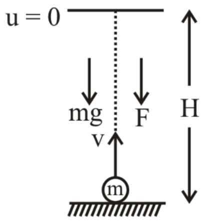
$\Delta T = 0.1^o$C

463. A ball of mass m is thrown upward with a velocity v. The air exerts an average resisting force F. The velocity with which the ball returns to the thrower is

(a) $v\sqrt{\frac{mg}{mg+F}}$	(b) $v\sqrt{\frac{F}{mg+F}}$
(c) $v\sqrt{\frac{F-mg}{F+mg}}$	(d) $v\sqrt{\frac{mg+F}{mg}}$

Assam CEE-2016

Ans. (c) :

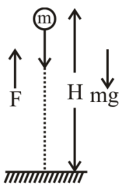


At maximum height speed of the ball is 0

By

$$\frac{1}{2}mv^2 = \text{Work Done}$$

$$\frac{1}{2}mv^2 = -FH - mgH \text{ --------(1)}$$



@apna_pdf

and, Work – Energy theorem,

$$\frac{1}{2}mv_1^2 = -FH + mgH \text{----------}(2)$$

Divide (1) by (2)

$$\frac{\frac{1}{2}mv^2}{\frac{1}{2}mv_1^2} = \frac{-(FH+mgH)}{-(FH-mgH)}$$

$$\frac{v^2}{v_1^2} = \frac{F+mg}{F-mg}$$

$$v_1^2 = \frac{F-mg}{F+mg} \times v^2$$

$$v_1 = v\sqrt{\frac{F-mg}{F+mg}}$$

(d) Elastic and Inelastic Collision

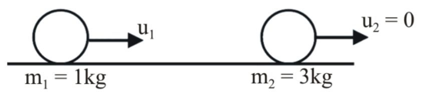
464. A body of mass 1 kg collides head on elastically with a stationary body of mass 3 kg. After collision, the smaller body reverses its direction of motion and moves with a speed of 2 m/s. The initial speed of the smaller body before collision is _______ms^{-1}.

JEE Main-25.01.2023, Shift-II

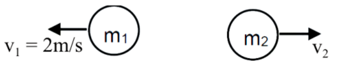
Ans. (4) : Given that, $m_1 = 1kg$, $m_2 = 3kg$

$u_1 = ?$, $u_2 = 0$

Before collision



After collision



From the conservation of momentum –

$m_1u_1 = m_1 \times (-2) + 3 \times v_2$

$u_1 = -2 + 3v_2$ ....(i)

We know that,

$$\text{Coefficient of restitution}(e) = \frac{v_2 - v_1}{u_1 - u_2}$$

For perfect elastic of collision, e = 1

$$1 = \frac{v_2 - (-2)}{u_1 - 0}$$

$u_1 = v_2 + 2$ ....(ii)

From equation (i) and equation (ii), we get –

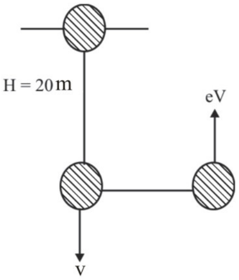
$u_1 = 4$ m/s and $v_2 = 2$ m/s

Hence, initial speed of smaller body before collision is 4 m/s.

465. A ball is dropped from a height of 20 m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a height of _____m.

JEE Main-31.01.2023, Shift-II

Ans. (5) Given, coefficient of restitution (e) = 0.5 and height (H) = 20m



We know that, $v = \sqrt{2gH}$ ....(i)

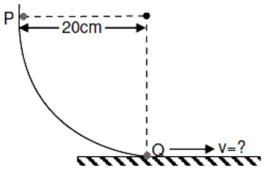
and $H_{max} = \frac{e^2v^2}{2g}$ .... (ii)

From equation (i) and equation (ii), we get –

$$H_{max} = \frac{e^2(2gH)}{2g}$$

$$H_{max} = \frac{1}{4} \times 20 = 5\,m$$

466. As per the given figure, a small ball P slides down the quadrant of a circle and hits the other ball Q of equal mass which is initially at rest. Neglecting the effect of friction and assume the collision to be elastic, the velocity of ball Q after collision will be:(g = 10 m/s^2)

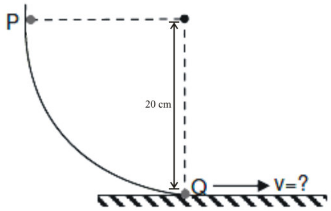


(a) 4 m/s (b) 0

(c) 0.25 m/s (d) 2 m/s

JEE Main-30.01.2023, Shift-I

Ans. (d) :



According to the energy conservation for object P between Q.

$$mgh = \frac{1}{2}mv_p^2$$

$$v_P = \sqrt{2gh} = \sqrt{2\times10\times0.2}$$

$$v_p = 2 \text{ m/s}$$

We know that, momentum conservation of the collision–

$$m_pv_p = m_Qv_Q$$

$$m \times 2 = mv_Q$$

$$v_Q = 2m/s$$

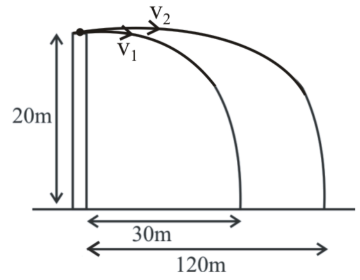
@apna_pdf

467. A ball of mass 200 g rests on a vertical post of height 20 m. A bullet of mass 10 g, travelling in horizontal direction, hits the centre of the ball. After collision both travels independently. The ball hits the ground at distance 30 m and the bullet at distance of 120 m from the foot of the post. The value of initial velocity of the bullet will be (if g = 10 m/s^2):

(a) 400 m/s (b) 360 m/s
(c) 60 m/s (d) 120 m/s

JEE Main-30.01.2023, Shift-I

Ans. (b) : Given, mass of ball (m_{ball}) = 200 g, mass of bullet (m_{bullet}) = 10 g and height (h) = 20m



$$v_1 = \frac{30}{\sqrt{\frac{2h}{g}}} \text{ and } v_2 = \frac{120}{\sqrt{\frac{2h}{g}}}$$

According to the conservation of momentum –

$$0.01u = 0.2\frac{30\sqrt{g}}{\sqrt{2h}} + (0.01)\frac{120\sqrt{g}}{\sqrt{2h}}$$

or $$u = 300 + 60 = 360\,m/s$$

468. Ball A of mass 50 gm an speed 10 m/s collides with other ball B of mass 10 gm and speed 15 m/s travelling in opposite direction with each other. Determine the final speed of ball B, if the coefficient of restitution is $\frac{2}{5}$.

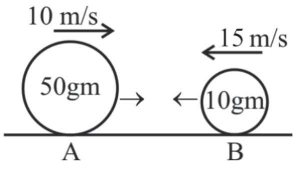
(a) $\frac{40}{3}m/s$ (b) $\frac{75}{3}m/s$
(c) $\frac{91}{8}m/s$ (d) $\frac{85}{6}m/s$

TS-EAMCET-04.05.2019, Shift-1
TS-EAMCET-05.05.2018, Shift-1

Ans. (d) : Given,

$m_A = 50$ g, $u_A = 10$ m/s
$m_B = 10$ g, $u_B = -15$ m/s

$$e = \frac{2}{5}$$



Final velocity of ball B –

$$v_B = \frac{m_A(1+e)}{m_A + m_B}u_A + \frac{m_B - em_A}{m_A + m_B}u_B$$

$$= \frac{50\left(1+\frac{2}{5}\right)}{50+10}\times 10 + \frac{\left(10 - \frac{2}{5}\times 50\right)}{50+10}(-15)$$

$$= \frac{50\times\frac{7}{5}\times 10}{60} + \frac{10}{60}\times 15$$

$$v_B = \frac{50\times 7\times 10}{60\times 5} + \frac{15}{6}$$

$$v_B = \frac{70}{6} + \frac{15}{6}$$

$$v_B = \frac{85}{6}m/s$$

469. In elastic collision

(a) both momentum and kinetic energy are conserved
(b) neither momentum nor kinetic energy is conserved
(c) only momentum is conserved
(d) only kinetic energy is conserved
(e) forces involved in the interaction and non-conservative

CG PET - 2006
Kerala CEE- 2005, 2014

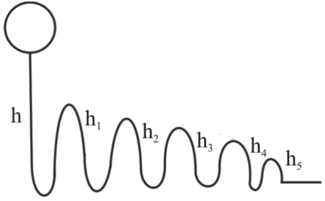
Ans. (a) : Both momentum and kinetic energy are conserved quantities in elastic collisions.

470. A ball is released from a height h. It hits the floor below and keeps bouncing repeatedly until it comes to rest. If the coefficient of restitution of the head-on collision between the ball and the floor is e (e > > 1), the total distance covered by the ball (vertically) from the point of its release to its rest position is given by

(a) $\frac{h(1-e^2)}{1+e^2}$ (b) $\frac{h(1+e^2)}{1-e^2}$
(c) $\frac{h(1-e)}{1+e}$ (d) $\frac{h(1+e)}{1-e}$

Assam CEE-2016,2019
EAMCET-2001

Ans. (b) :



Let, m is the mass of ball

$$mgh = \frac{1}{2}mv^2$$

$$v^2 = 2gh \qquad \text{.... (i)}$$

Let after first hit, the bounce of height is h_1 and velocity is v_1-

$$\frac{1}{2}mv_1^2 = mgh_1 \qquad \left(\because\ e = \frac{v_1}{v}\right)$$

@apna_pdf

$$v_1^2 = 2gh_1$$

$$(ev)^2 = 2gh_1$$

Putting the value of v^2 from equation (i), we get

$$e^2.2gh = 2gh_1$$

$$h_1 = e^2h$$

Similarly –

$$mgh_2 = \frac{1}{2}mv_2^2 \quad \text{(Second hit)}$$

$$gh_2 = \frac{1}{2}v_2^2 \quad \left(\frac{v_2}{v_1} = e\right)$$

$$gh_2 = \frac{1}{2}(ev_1)^2$$

$$gh_2 = \frac{1}{2}e^2 2gh_1$$

$$h_2 = e^2h_1 = e^4h$$

Similarly, $h_3 = e^6h$ ……..So on

For n terms, $h_n = e^{2n}h$

So,

Total distance covered by the ball (Vertically)

$H = h + 2h_1 + 2h_2 + 2h_3 + ………$

$= h + 2e^2h + 2e^4h + 2e^6h + ……..$

$= h(1 + 2e^2 + 2e^4 + 2e^6 + …….)$

$$\left[\text{We know, } 1 + e^2 + e^4 + ... = \frac{1}{1-e^2}\right]$$

$$= h\left[1 + 2e^2\left(\frac{1}{1-e^2}\right)\right]$$

$$\therefore \quad H = \frac{h(1+e^2)}{(1-e^2)}$$

471. For inelastic collision between two spherical rigid bodies :

(a) the total kinetic energy is conserved
(b) the total mechanical energy is not conserved
(c) the linear momentum is not conserved
(d) the linear momentum is conserved

UP CPMT-2006
JIPMER-2008
UPSEE - 2006

Ans. (d) : In an inelastic collision the particles do not region their size and shape completely after collision.
Thus, kinetic energy of particles no longer remains conserved. In the absence of external forces, law of conservation of linear momentum remains conserved.

472. A hammer weighing 3 kg strikes the head of a nail with a speed of 2 ms^{-1} and drives it 1 cm into the wall. The impulse imparted to the wall is _____.

(a) 6 N s
(b) 3 N s
(c) 2 N s
(d) 18 N s

AP EAMCET-07.09.2021, Shift-I
Kerala CEE-2014

Ans. (a) : Given, initial velocity (u) = 2m/ s, velocity after strike (v) = 0

Impulse = Change in momentum of the body

Impulse = $\Delta p = p_i - p_f$

$= mu - mv$

$= m(u - v)$

$= 3(2 - 0)$

Impulse = 6 N.sec

473. A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. After the collision, if both balls move together, the loss in kinetic energy due to collision is____

(a) 40 J (b) 60 J
(c) 100 J (d) 140 J

AP EAMCET-19.08.2021, Shift-I
VITEEE- 2016

Ans. (b) : Given, $m_1 = 2kg$, $m_2 = 3kg$, $v_1 = 36$ km/h $= 36 \times \frac{5}{18} = 10$ m/s, $v_2 = 0$

According to law of conservation of momentum –

$m_1v_1 + m_2v_2 = (m_1 + m_2)v$

$2 \times 10 + 0 = (2 + 3)v$

$20 = 5v$

$v = 4$ m/s

$$\text{Loss of K.E.} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

$$= \frac{1}{2} \times 2 \times 100 + 0 - \frac{1}{2} \times 5 \times 16$$

$= 100 - 40$

$= 60$ J

474. The coefficient of restitution for a perfect elastic collision is ________.

(a) 1 (b) 0
(c) ∞ (d) –1

AP EAMCET-23.08.2021, Shift-II
AIPMT - 1988

Ans. (a) : The value of coefficient of restitution in perfectly elastic collision is 1.

$$\text{Coefficient of restitution} = \frac{\text{Relative speed after collision}}{\text{Relative speed before collision}}$$

475. Assertion (A): In an elastic collision of two billiard balls, the total K.E. is conserved during the short time of collision of the balls (i.e. when they are in contact).

Reason (R) : Energy spent against friction does not follow the law of conservation of energy.

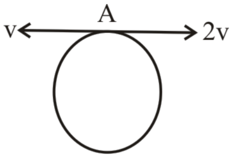
(a) Both (A) and (R) are true and (R) is a correct explanation for (A).
(b) Both (A) and (R) are true but (R) is not a correct explanation for (A).
(c) (A) is true, (R) is false
(d) (A) is false, (R) is false

AP EAMCET-25.08.2021, Shift-II
AIIMS-2002

@apna_pdf

Ans. (d) : The billiard balls in an elastic collision are in a deformed state. Their total energy is in the form of potential energy and kinetic energy. Energy spent against friction should be considered when calculating total energy. Law of conservation of energy always applies in every case. Only note is to identify the forms of energy. Reason is also false.

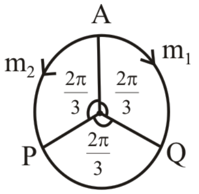
476. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and 2v respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A, these two particles will again reach the point A?



(a) 4 (b) 3
(c) 2 (d) 1

AMU-2017
AIEEE-2009

Ans. (c) : Two masses are moving in the circular orbit starting from A. m_1, the particle with velocity 2v moves to P by AQP, while the particle with velocity (v), m_2 reaches P from A.



At P, they make elastic collision, then m_2 moves back to Q by PAQ as it has now velocity 2v and m_1 comes back from P to Q to make collision once more. Now m_1 has velocity 2v and m_2 has velocity v. So the particles reach A after two collisions.

477. A smooth sphere of mass M moving with velocity u directly collides elastically with another sphere of mass m at rest. After collision, their final velocities are V and v respectively. The value of v is

(a) $\frac{2uM}{m}$ (b) $\frac{2um}{M}$

(c) $\frac{2u}{1+\frac{m}{M}}$ (d) $\frac{2u}{1+\frac{M}{m}}$

MHT CET - 2020
VITEEE-2017

Ans. (c) We know that,
Coefficient of restitution,

$$-e = \frac{V-v}{u-0}$$

For elastic Collision, (e = 1),

$$\therefore \quad \frac{V-v}{u-0} = -1$$

$$V - v = -u$$

$$V = v - u \qquad \text{...(i)}$$

By law of conservation of momentum,
Mu + 0 = MV + mv
using equation (i)
Mu = M (v–u) + mv
Mu = Mv – Mu + mv
= 2mu = v (M+v)

$$v = \frac{2Mu}{M+m}$$

$$v = \frac{2u}{1+\frac{m}{M}}$$

478. A cricket ball is dropped from a building of height 30m and the coefficient of restitution between the ground and ball is 0.5. The total distance covered by the ball before it comes to rest is

(a) 60 m (b) 10 m
(c) 18 m (d) 50 m

TS EAMCET 30.07.2022, Shift-II

Ans. (d) : Given, height (h) = 30 m, coefficient of restitution (e) = 0.5

We know, total distance travelled $(D) = h\left(\frac{1+e^2}{1-e^2}\right)$

$$D = \frac{30\times(1+0.25)}{(1-0.25)}$$

$$= \frac{30\times1.25}{0.75} = 50 \text{ m}$$

479. Which one of the following statement is correct?

(a) In inelastic collisions, both momentum and kinetic energy are conserved
(b) In inelastic collisions, momentum is conserved and kinetic energy is not conserved
(c) In elastic collisions, momentum is conserved and kinetic energy is not conserved
(d) In inelastic collisions, momentum is not conserved and kinetic energy is conserved
(e) In elastic collisions, momentum is not conserved and kinetic energy is conserved

Kerala CEE 04.07.2022

Ans. (b) : Inelastic collision: An inelastic collision is such a type of collision that takes place between two objects in which some energy is loss. In the case of inelastic collision momentum is conserved but the kinetic energy is not conserved.

Elastic collision: Any collision in which the collided objects get separated after the collision is known as an elastic collision.

In the case of elastic collision both momentum and kinetic energy are conserved.

@apna_pdf

480. Two balls A and B, of masses M and 2 M respectively collide each other. If the ball A moves with a speed of 150 ms^{-1} and collides with ball B moving with speed v in the opposite direction. After collision if ball A comes to rest and the coefficient of restitution is 1 (one), then the speed of the ball B before it collides with ball A is

(a) 37.5 ms^{-1}

(b) 12.5 ms^{-1}

(c) 75 ms^{-1}

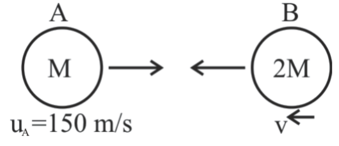
(d) 25 ms^{-1}

AP EAMCET-04.07.2022, Shift-II

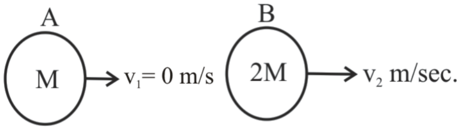
Ans. (a) : Given, $m_A = M$, $m_B = 2M$

$u_A = 150\text{ms}^{-1}$, $u_B = v$

$v_A = 0$, $v_B = v_2$



Before collide



After collision

By the law of conservation of momentum-

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

$$M \times 150 + 2M \times v = M \times 0 + 2M \times v_2$$

$$v_2 = \frac{150+2v}{2}$$

$$v_2 = 75+v \quad \dots (i)$$

$$\because \quad -e = \frac{v_2 - v_1}{u_2 - u_1}$$

$$-1 = \frac{v_2 - 0}{v - 150}$$

$$v_2 = -v+150 \quad \dots (ii)$$

From equation (i) and (ii)

$$75 + v = -v+150$$

$$2v = 75$$

$$v = 37.5\text{m/sec.}$$

∴ Velocity of ball B before collision is 37.5 m/sec.

481. Ball A of mass 1 kg moving along a straight line with a velocity of 4 m s^{-1} hits another ball B of mass 3 kg which is at rest. After collision, they stick together and move with the same velocity along the same straight line. If the time of impact of the collision is 0.1 s then the force exerted on B is

(a) 30 N (b) 24 N

(c) 36 N (d) 27 N

AP EAMCET-05.07.2022, Shift-I

Ans. (a) : Given, $m_1 = 1$ kg, $u_1 = 4$ m/s, $m_2 = 3$ kg

$u_2 = 0$, $t = 0.1$ sec,

$$p_i = m_1 u_1 + m_2 u_2$$

$$= 1 \times 4 + 3\times 0$$

$$p_i = 4 \text{ kg m/s}$$

After collision they stick i.e.$(m_1 + m_2) = 4$kg

$$p_i = p_f$$

$$4 = 4v$$

$$v = 1 \text{ m/s}$$

$$\because \quad F = m.a \qquad \left(\because \quad a = \frac{v}{t}\right)$$

$$F = m.\frac{v}{t}$$

$$F = 3\times\frac{1}{0.1}$$

$$F = 30 \text{ N}$$

482. A ball of mass 0.15 kg hits the wall with its initial speed of 12 ms^{-1} and bounces back without changing its initial speed. If the force applied by the wall on the ball during the contact is 100 N. calculate the time duration of the contact of ball with the wall.

(a) 0.018 s (b) 0.036 s

(c) 0.009 s (d) 0.072 s

JEE Main-26.07.2022, Shift-II

Ans. (b) : Given,

Mass of ball (m) = 0.15 kg

Initial speed of ball (u) = 12m/s

$v = -12$ m/s, $F = 100$ N, $\Delta t = ?$

Initial momentum $(p_i) = mu = 12 \times 0.15$

$$p_i = 1.8 \text{ kgm/s}$$

Final momentum $(p_f) = mv = -12 \times 0.15$

$$p_f = -1.8 \text{ kgm/s}$$

Change in momentum,

$$\Delta p = p_i - p_f = 1.8 - (-1.8)$$

$$\Delta p = 3.6 \text{ kg m/s}$$

We know that,

Change in momentum $(\Delta p) = F \times \Delta t$

$$\Delta t = \frac{\Delta P}{F} = \frac{3.6}{100} = 0.036\text{s}$$

483. Two objects I and II of mass 0.8 kg and 0.6 kg collide elastically. If before collision, the object II was at rest and object I was moving. Find the ratio of the final velocity of object I and object II.

(a) 6 : 7 (b) 4 : 3

(c) 1 : 8 (d) 1 : 16

TS EAMCET 30.07.2022, Shift-I

Ans. (c) : Given, $m_1 = 0.8$kg, $m_2 = 0.6$kg,

$u_2 = 0$

$e = 1 \quad (\because \text{elastically collide})$

Law of conservation of momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$0.8u_1 + 0 = 0.8v_1 + 0.6v_2$$

$$0.8v_1 + 0.6v_2 = 0.8u_1 \quad \dots(i)$$

Newton's experimental law

$$v_2 - v_1 = e\,(u_1 - u_2) \qquad (\because e = 1)$$

$$v_2 - v_1 = 1\,(u_1 - 0)$$

$$u_1 = v_2 - v_1 \quad \dots\dots (ii)$$

@apna_pdf

From equation (i), we get

$$0.8v_1 + 0.6v_2 = 0.8(v_2 - v_1)$$

$$0.8v_1 + 0.6v_2 = 0.8v_2 - 0.8v_1$$

$$1.6v_1 = 0.2v_2$$

$$\frac{v_1}{v_2} = \frac{2}{16}$$

$$v_1 : v_2 = 1 : 8$$

484. Two identical bodies of same mass move with speed V_0 an $2V_0$, respectively in directions perpendicular to each other. After some time, the bodies collide and merge with each other. The speed after collision is

(a) $\frac{V_0}{2}$ (b) $\frac{V_0\sqrt{5}}{2}$

(c) $\frac{V_0}{2\sqrt{5}}$ (d) V_0

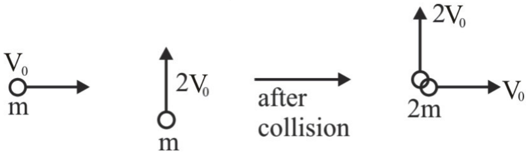
TS EAMCET 31.07.2022, Shift-II

Ans. (b) : Given,

Two identical bodies of same mass i.e. $m_1 = m_2 = m$

Moving with speed V_0 and $2V_0$

$\because$ Bodies are moving in perpendicular direction,



On x-axis, let speed after collision in x-direction is V_1,

$mV_0 + 0 = 2mV_1$

$V_1 = V_0/2$

On y-axis, let speed after collision in y-direction is V_2,

$$m(2V_0) = 2mv_2$$

$$V_2 = V_0$$

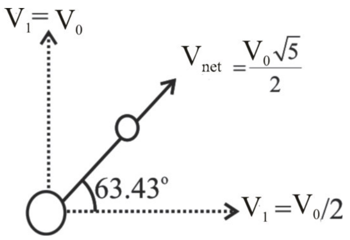
Hence, net speed after collision

$$V_{net} = \sqrt{V_1^2 + V_2^2}$$

$$= \sqrt{(V_0/2)^2 + V_0^2}$$

$$= \sqrt{\frac{V_0^2 + 4V_0^2}{4}}$$

$$V_{net} = \frac{V_0\sqrt{5}}{2}$$



$$\tan\theta = \frac{V_0}{V_0/2} = 2$$

$$\boxed{\theta = 63.43^\circ}$$

485. A body of mass 'M' collides against a wall with a speed 'v' and retraces its path with the same speed, the change in momentum is

(a) Zero (b) 2 Mv

(c) Mv (d) –Mv

TS EAMCET 31.07.2022, Shift-II

Ans. (b) : Given, mass = M, speed = v

Assuming ball was travelling in (+X) direction initially,

Then, initial momentum $P_i = Mv$

After collision ball will move in (–X) direction,

Then, final momentum $P_f = -Mv$

Now, change in momentum $= P_i - P_f$

$$= Mv - (-Mv) = 2\,Mv$$

486. Which of the following statement is "CORRECT"?

(a) In an elastic collision of two bodies, the momentum and energy of each body is conserved

(b) Total energy of a system is always conserved, no matter what internal and external forces on the body are present

(c) Work done in the motion of a body over a closed loop is zero for every force in nature

(d) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system.

TS EAMCET 30.07.2022, Shift-II

Ans. (a) : • In an elastic collision both the momentum and kinetic energy remain conserved.

• The external force on the system may increases or decreases the total energy of the system.

• Work done in the motion of a body over a closed loop is zero only when the body is moving under the action of conservation forces (i.e. gravitational & electrostatic forces). It is not zero when the forces are non-conservative (i.e. frictional forces).

487. Particle A moving with a velocity $v = 10$m/s experienced a head on collision with a stationary particle B of the same mass. As a result of collision, the kinetic energy of the system decreased by 1%. The speed of particle A after collision is

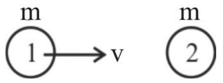
(a) 10 m/s (b) 0.05 m/s

(c) 5 m/s (d) $10\sqrt{2}$ m/s

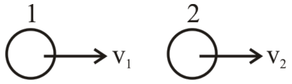
TS EAMCET 19.07.2022, Shift-II

Ans. (c) : Given,

$$m_1 = m_2 = m,\ v = 10\text{ m/s},\ \eta = 1\% = \frac{1}{100}$$



Head- on collision



By momentum conservation,

$mv = mv_1 + mv_2 \Rightarrow v = v_1 + v_2$ ....(i)

@apna_pdf

Friction loss in KE of 1 & 2,

$$\eta = \frac{\text{Initial KE} - \text{Final KE}}{\text{Initial KE}}$$

$$\Rightarrow \qquad \eta = \frac{\frac{1}{2}mv^2 - \left(\frac{1}{2}mv_1{}^2 + \frac{1}{2}mv_2{}^2\right)}{\frac{1}{2}mv^2}$$

$$\eta v^2 = v^2 - (v_1{}^2 + v_2{}^2)$$

$$(1-\eta)v^2 = v_1{}^2 + v_2{}^2 \qquad \text{....(ii)}$$

From equation (i) and (ii)

$$v_1{}^2 + (v - v_1)^2 = (1-\eta)v^2$$

Or, $\quad v_1{}^2 + v^2 + v_1{}^2 - 2vv_1 = (1-\eta)v^2$

Or, $\quad 2v_1{}^2 - 2vv_1 + \eta v^2 = 0$

So,

$$v_1 = \frac{2v \pm \sqrt{4v^2 - 8\eta v^2}}{4}$$

$$v_1 = \frac{1}{2}\left[v \pm \sqrt{v^2 - 2\eta v^2}\right] = \frac{1}{2}v\left(1 \pm \sqrt{1-2\eta}\right)$$

Positive sign gives the velocity of the 2nd particle which lies ahead.

The negative sign is correct for v_1

So,

$$v_1 = \frac{1}{2}v\left(1 - \sqrt{1-2\eta}\right)$$

$$v_1 \approx \frac{1}{2}v$$

$$v_1 = \frac{1}{2} \times 10$$

$$v_1 = 5 \text{ m/sec}$$

488. Assertion (A): In an elastic collision of two billiard balls, both kinetic energy and linear momentum remain conserved.

Reason (R) During the collision of the balls, as the collision is elastic there is no exchange of energy. Therefore, both energy and momentum are conserved.

The correct option among the following is

(a) (A) is true (R) is true and (R) is the correct explanation for (A)

(b) (A) is true (R) is true but (R) is not the correct explanation for (A)

(c) (A) is true but (R) is false

(d) (A) is false but (R) is true

TS EAMCET 19.07.2022, Shift-I

Ans. (c) : In an elastic collision of two billiard balls both kinetic energy and linear momentum remain conserved because an elastic collision is a collision in which there is no net loss in kinetic energy in the system due to the collision. Both momentum and kinetic energy are conserved in an elastic collision. Since at the point of collision the total kinetic energy is converted into potential energy in the form of deformation. So they are equal amount of energy exchange between both the bodies in the elastic collision.

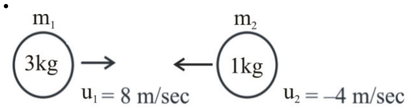
489. A body of mass 3 kg is moving with a velocity of 8 m.s^{-1} collides head on with another body of mass 1 kg moving in the opposite direction with a velocity of 4 m.s.$^{-1}$. After the collision, if the two bodies stick together and move, they move with a common velocity ______.

(a) 5 ms^{-1} (b) 7 ms^{-1}

(c) 10 ms^{-1} (d) 14 ms^{-1}

AP EAMCET-25.08.2021, Shift-II

Ans. (a) :



Let after collision the common velocity (v) = $v_1 = v_2$

According to law of conservation on of momentum –

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$3 \times 8 + 1 \times (-4) = 3v + 1 \times v$$

$$24 - 4 = 4v$$

$$20 = 4v$$

$$v = 5 \text{ m/sec}$$

490. In perfectly inelastic collisions the relative velocity of the bodies:

(a) Before impact is zero

(b) Before impact is equal to that after impact

(c) After impact is zero

(d) Is characterized by none of the above

AP EAMCET-24.08.2021, Shift-II

Ans. (c) : In a perfect inelastic collision, two bodies stick together after the collision and move with same velocity, so there relative velocity after the impact is zero.

491. An object A of mass 20 kg and travelling at 20 m/s crashes into another object B of mass 200 kg and travelling at 10 m/s, in the same direction. After the collision, object A bounces back in opposite direction at a speed of 10 m/s . The speed of the object B after the collision is:

(a) 13 m/s (b) 12 m/s

(c) 14 m/s (d) 20 m/s

TS EAMCET 05.08.2021, Shift-II

Ans. (a) : Given, $m_A = 20$ kg, $u_A = 20$ m/s, $m_B = 200$ kg $u_B = 10$ m/s, $v_A = -10$ m/s, $v_B = ?$

Let the speed of B after the collision be v_B.

By the conservation of linear momentum before and after the collision,

$$p_i = p_f$$

$$m_Au_A + m_Bu_B = m_Av_A + m_Bv_B$$

$$20 \times 20 + 200 \times 10 = 20 \times (-10) + 200\, v_B$$

$$400 + 2000 = -200 + 200\, v_B$$

$$2400 + 200 = 200\, v_B$$

$$v_B = \frac{2600}{200}$$

$$v_B = 13 \text{ m/s}$$

492. A moving body of mass m and velocity 3 km/h collides with a body at rest mass 2 m and sticks to it. Now the combined mass starts to move with speed of.

(a) 1 km/h (b) 2 km/h

(c) 3 km/h (d) 4 km/h

AP EAMCET-25.09.2020, Shift-II

@apna_pdf

Ans. (a) : Given,

$m_1 = m$

$v_1 = 3$ km/h

$m_2 = 2m$

$v_2 = 0$

From the law of momentum–

$m_1 v_1 = (m_1+m_2)v_2$

$m\times 3 = (m+2m)v_2$

$v_2 = 1$ km/h

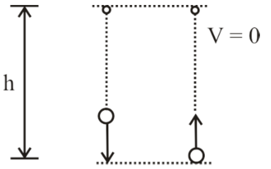
493. A ball is projected vertically down with an initial velocity from a height 10 m onto a horizontal floor. During the impact it loses 20% of the energy and rebounds to the same height. What is the initial velocity of its projection?
(Use $g = 10\ m/s^2$)

(a) $5\sqrt{2}\,m/s$ (b) $10\sqrt{3}\,m/s$
(c) $5\sqrt{3}\,m/s$ (d) $10\sqrt{2}\,m/s$

TS EAMCET 28.09.2020, Shift-II

Ans. (a) : Let a ball is projected vertically downward with velocity v from height h

Total energy at point $A = \frac{1}{2}mv^2 + mgh$



During collision loss of energy is 20% and the ball rises up to same height.

$$\left(\frac{1}{2}mv^2 + mgh\right)80\% = mgh$$

$$\left(\frac{1}{2}mv^2 + mgh\right)\frac{4}{5} = mgh$$

$$\frac{v^2}{2} + gh = \frac{5gh}{4}$$

$$\frac{v^2}{2} = \frac{5gh}{4} - gh$$

$$\frac{v^2}{2} = gh\left(\frac{5}{4} - 1\right)$$

$$v^2 = \frac{gh}{4}\times 2$$

$$v^2 = \frac{gh}{2}$$

$$v = \sqrt{\frac{10\times 10}{2}}$$

$$\boxed{v = 5\sqrt{2}\ m/s}$$

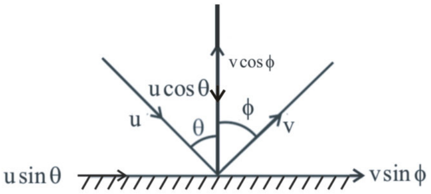
494. A tennis ball hits the floor with a speed v at an angle θ with the normal to the floor. If the collision is inelastic and the coefficient of restitution is ε, what will be the angle of reflection?

(a) $\tan^{-1}\left(\frac{\tan\theta}{\varepsilon}\right)$ (b) $\sin^{-1}\left(\frac{\sin\theta}{\varepsilon}\right)$

(c) $\theta\varepsilon$ (d) $\theta\frac{2\varepsilon}{\varepsilon+1}$

WB JEE 2020

Ans. (a) : Velocity of approach = normal component of velocity.



Along horizontal direction momentum is conserved.

$v\sin\phi = u\sin\theta$ ....(i)

Along the vertical

$$\varepsilon = \frac{v\cos\phi}{u\cos\theta} = \frac{\sin\theta}{\sin\phi}\times\frac{\cos\phi}{\cos\theta} \qquad \left[\because \frac{v}{u} = \frac{\sin\theta}{\sin\phi}\right]$$

$$\Rightarrow \quad \varepsilon = \frac{\tan\theta}{\tan\phi}$$

$$\Rightarrow \quad \tan\phi = \frac{\tan\theta}{\varepsilon}$$

$$\Rightarrow \quad \boxed{\phi = \tan^{-1}\left(\frac{\tan\theta}{\varepsilon}\right)}$$

495. A block of mass 'm' collides with another stationary block of mass '2m'. The lighter block comes to rest after collision. If the velocity of first block is 'u', then the value of coefficient of restitution is

(a) 0.8 (b) 0.4
(c) 0.5 (d) 0.6

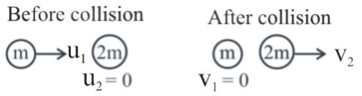
MHT-CET 2020

Ans. (c) : Given,

$m_1 = m,\ m_2 = 2m$

$u_1 = u,\ \ u_2 = 0$

$v_1 = 0,\ \ v_2 = v'$



By law of conservation of momentum:-

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$mu = m(0) + 2m\,v'$

$$v' = \frac{u}{2} \qquad ....(i)$$

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

$$e = \frac{v' - 0}{u - 0} = \frac{v'}{u} \qquad ....(ii)$$

Putting the value of v' in equation (ii), we get –

$$e = \frac{u}{2u} = \frac{1}{2} = 0.5$$

@apna_pdf

496. A block of mass 'm' moving on a frictionless surface at speed 'V' collides elastically with a block of same mass, initially at rest, Now the first block moves at an angle 'θ' with its initial direction and has speed 'V_1'. The speed of the second block after collision is

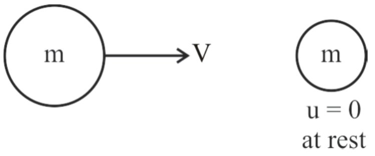
(a) $\sqrt{V^2 - V_1^2}$ (b) $\sqrt{V_1^2 - V^2}$

(c) $\sqrt{V^2 + V_1^2}$ (d) $\sqrt{V - V_1}$

MHT-CET 2020, 2019

Ans. (a) : Given, $m_1 = m_2 = m$

$u_1 = V, u_2 = 0$



From conservation of K.E–

K.E before the collision and K.E. after the collision are equal.

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1V_1^2 + \frac{1}{2}m_2V_2^2$$

$$\frac{1}{2}mV^2 + 0 = \frac{1}{2}mV_1^2 + \frac{1}{2}mV_2^2$$

$$V^2 = V_1^2 + V_2^2$$

$$V_2^2 = V^2 - V_1^2$$

$$V_2 = \sqrt{V^2 - V_1^2}$$

497. A mass m moving with velocity 'v' along x axis collides and sticks to another mass 2m which is moving along Y axis with velocity 3v. After collision, the velocity of the combination is

(a) $\frac{v}{3}\hat{i} - 2v\hat{j}$ (b) $v\hat{i} + \frac{v}{3}\hat{j}$

(c) $\frac{2v}{3}\hat{i} + \hat{j}$ (d) $\frac{v}{3}\hat{i} + 2v\hat{j}$

MHT-CET 2020

Ans. (d) : Given,

$m_1 = m, m_2 = 2m, u_1 = v, u_2 = 3v,$

$v_1 = v_2$ (because both the masses stick)

Applying the law of conservation of linear momentum–

$$(m_1u_1)\hat{i} + (m_2u_2)\hat{j} = m_1v_1 + m_2v_2 = (m_1 + m_2)v_2$$

$$(mv)\hat{i} + (2m \times 3v)\hat{j} = 3m\vec{v}_2$$

$$v\hat{i} + 6v\hat{j} = 3\vec{v}_2$$

$$\vec{v}_2 = \frac{v}{3}\hat{i} + 2v\hat{j}$$

498. A ball falls in the downward direction from height 'h' with initial velocity V. It collides with ground, loses $\left(\frac{3}{4}\right)^{th}$ of energy and comes back to the same height. The initial velocity 'V' is (g=acceleration due to gravity)

(a) $\sqrt{gh}$ (b) $\sqrt{2gh}$

(c) $\sqrt{3gh}$ (d) $\sqrt{6gh}$

MHT-CET 2020

Ans. (d) : Total energy $(\text{at } h) = \frac{1}{2}mV^2 + mgh$

Energy of ball after collision $= \frac{1}{4}\left(\frac{1}{2}mV^2 + mgh\right)$

As the ball rebounds to the same height-

$$\therefore mgh = \frac{1}{4}\left(\frac{1}{2}mV^2 + mgh\right) = \frac{1}{8}mV^2 + \frac{1}{4}mgh$$

$$mgh - \frac{1}{4}mgh = \frac{1}{8}mV^2$$

$$\frac{3}{4}mgh = \frac{1}{8}mV^2$$

$$V^2 = 6gh$$

$$V = \sqrt{6gh}$$

499. A wooden block of mass 'M' moves with velocity 'v' and collides with another block of mass '4M' which is at rest. After collision the block of mass 'M' comes to rest. The coefficient of restitution will be

(a) 0.25 (b) 0.15

(c) 0.05 (d) 0.30

MHT-CET 2020

Ans. (a) : Given,

$m_1 = M, m_2 = 4M$

$u_1 = v, u_2 = 0, v_1 = 0$ and $v_2 = ?$

Since, the collision mentioned is an elastic head on collision. Thus, according to the law of conservation of linear momentum, we get –

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$Mv + 4M \times 0 = 0 + 4M \times v_2$$

$$Mv = 4\,Mv_2$$

$$v_2 = \frac{v}{4}$$

We know, co-efficient of restitution

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

$$e = \frac{\frac{v}{4} - 0}{v - 0}$$

$$e = 0.25$$

500. For a perfectly elastic collision, the coefficient of restitution e is

(a) 1 (b) 0.75

(c) zero (d) 0.5

MHT-CET 2020

Ans. (a) : We know that,

$$\text{Coefficient of restitution } (e) = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

- for perfectly elastic collision, e = 1
- for perfectly inelastic collision, e = 0
- for other collision, $0 < e < 1$

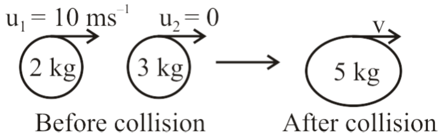
@apna_pdf

501. A metal ball of mass 2 kg moving with a speed of 10 ms^{-1} had a head-on collision with a stationary ball of mass 3 kg. If after collision, both the balls move together, then the loss in kinetic energy due to collision is

(a) 100 J (b) 60 J
(c) 40 J (d) 140 J

MHT-CET 2020

Ans. (b) : Given that, $m_1 = 2kg$, $m_2 = 3kg$



Initial kinetic energy $K_1 = \frac{1}{2}m_1u_1^2$

$$= \frac{1}{2} \times 2 \times (10)^2$$

$= 100$ J

Applying law of conservation of momentum,

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

$$v = \frac{m_1u_1 + m_2u_2}{(m_1 + m_2)}$$

$$= \frac{2\times10+0}{2+3} = \frac{20}{5} = 4 m/s \quad (\because u_2 = 0)$$

$\therefore$ Final kinetic energy, $K_2 = \frac{1}{2}(m_1 + m_2)v^2$

$$= \frac{1}{2} \times 5 \times (4)^2$$

$$= \frac{5\times16}{2} = 40J$$

$\therefore$ Loss of Kinetic energy, $K_1 - K_2 = 100 - 40$

$= 60J$

502. A ball at rest falls vertically on ground from a height of 5m. The coefficient of restitution is 0.4. The maximum height of the ball after the first rebound is (g = 10 m/s^2)

(a) 0.6 m (b) 0.2 m
(c) 0.8 m (d) 0.4 m

MHT-CET 2020

Ans. (c): Given that,

$h_1 = 5m$

$h_2 = ?$

Coefficient of restitution (e) = 0.4

We know that:

The coefficient of restitution, $e = \sqrt{\frac{h_2}{h_1}}$

$$\therefore \quad e^2 = \frac{h_2}{h_1}$$

$$h_2 = e^2h_1$$

$$= (0.4)^2\times5$$

$$= 0.16\times5$$

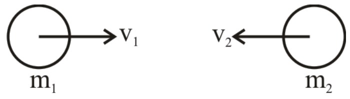
$$= 0.8 \text{ m}$$

503. Two masses 'm$_1$' and 'm$_2$' moving with velocities 'v$_1$' and 'v$_2$' in opposite directions collide elastically and after collision 'm$_1$' and 'm$_2$' move with velocity 'v$_2$' and 'v$_1$' respectively. The ratio v$_2$/v$_1$ is

(a) 0.5 (b) 0.25
(c) 1 (d) 0.75

MHT-CET 2020

Ans. (c) : Initially:–



But after collision:–

Now, by conservation of momentum–

$$p_i = p_f$$

$$m_1v_1 - m_2v_2 = -m_1v_2 + m_2v_1$$

$$m_1v_1 + m_1v_2 = m_2v_1 + m_2v_2$$

$$m_1(v_1 + v_2) = m_2(v_1 + v_2)$$

$$\frac{m_1}{m_2} = 1$$

Hence, we know that mass is inversely proportional to velocity therefore –

$$\frac{v_2}{v_1} = 1$$

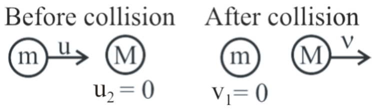
Thus, the ratio of $v_2 : v_1 = 1 : 1$

504. A particle of mass 'm' collides with another stationery particle of mass 'M'. The particle of mass 'm' stops just after collision. The coefficient of restitution is

(a) $\frac{M}{m}$ (b) $\frac{m+M}{m}$
(c) $\frac{m}{M}$ (d) $\frac{M-m}{M+m}$

MHT-CET 2020

Ans. (c) :



Given that, $m_1 = m$, $m_2 = M$

$u_1 = u$, $u_2 = 0$

$v_1 = 0$, $v_2 = v$

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

So, $$e = \frac{v-0}{u-0} = \frac{v}{u} \quad \ldots(i)$$

From linear momentum conservation

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

@apna_pdf

$$mu = Mv$$

$$\frac{m}{M} = \frac{v}{u} \qquad \ldots(ii)$$

From equation (i) and (ii), we get –

$$\boxed{e = \frac{m}{M}}$$

505. A ball of mass 'm' falls from height 'h' on a floor for which the coefficient of restitution is 'e'. After two rebounds, the height attained by the ball is

(a) $\sqrt{eh}$ (b) eh
(c) e^2h (d) e^4h

MHT-CET 2020

Ans. (d) : We know that,
Coefficient of restitution is given by-

$$e = \sqrt{\frac{h_2}{h_1}}$$

$$e^2 = \frac{h_2}{h_1}$$

$$h_2 = e^2 h_1$$

Similarly, $h_3 = e^2h_2$

$$h_3 = e^2 (e^2h_1) \qquad (\because h_2 = e^2h_1)$$

$$h_3 = e^4h_1$$

$$\boxed{h_3 = e^4h} \qquad (\because h_1 = h)$$

506. A ball kept at 20 m height falls freely in downward direction vertically and hits the ground. The coefficient of restitution is 0.4. After the first rebound the upward velocity is g= 10 m/s^2

(a) 4 m/s (b) 8 m/s
(c) 16 m/s (d) 12 m/s

MHT-CET 2020

Ans. (b) : Given that,
$h = 20m, \quad e = 0.4$
From equation of third law of motion,

$$v^2 = u^2 + 2gh$$
$$v^2 = 0 + 2gh$$
$$v^2 = 2 \times 10 \times 20$$
$$v^2 = 400$$
$$v = 20 \text{ m/s}$$

We know,

$$e = \frac{u}{v}$$

So, $u = ev = 0.4 \times 20 = 8$ m/s

507. A metal ball released from height 'h' makes perfectly elastic collision with ground. The frequency of periodic vibratory motion is (g = acceleration of due to gravity)

(a) $\frac{1}{2}\sqrt{\frac{2h}{g}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{g}{2h}}$
(c) $\frac{1}{2\pi}\sqrt{\frac{2h}{g}}$ (d) $\frac{1}{2}\sqrt{\frac{g}{2h}}$

MHT-CET 2020

Ans. (d) : We know that initial velocity of ball will be zero because they starts from rest i.e. u = 0
From second equation of motion –

$$h = ut + \frac{1}{2}gt^2 \qquad (\because u = 0)$$

$$h = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

Time period of oscillation (T) = $2t \Rightarrow 2\sqrt{\frac{2h}{g}}$

$\therefore$ Frequency $(f) = \frac{1}{T} \Rightarrow \frac{1}{2}\sqrt{\frac{g}{2h}}$

508. A body of mass 'm' is suspended from the rigid support by an inextensible string of length 'L' on which another identical body of mass 'm' struck in-elastically moving with horizontal velocity $\sqrt{2gL}$. The increase in the tension just after it is struck by the body is (g = acceleration due to gravity)

(a) mg (b) 4 mg
(c) 2 mg (d) 3 mg

MHT-CET 2020

Ans. (c) : Given,
velocity (v) = $\sqrt{2gL}$
mass = m
$T_1 = mg$
If the mass m is given then velocity = $\sqrt{2gL}$
Then the body moves in a circular path and the tension is given by

$$T_2 = mg + \frac{mv^2}{L}$$
$$= mg + \frac{m(2gL)}{L}$$
$$= mg + 2mg$$
$$T_2 = 3mg$$

Increase tension = $T_2 - T_1$
$= 3mg - mg = 2mg$

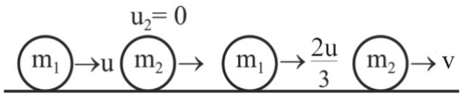
509. A moving body with a mass m_1 and velocity u strikes a stationary body of mass m_2. The masses m_1 and m_2 should be in the ratio $\frac{m_1}{m_2}$, so as to decrease the velocity of the first body to $\frac{2u}{3}$ and giving a velocity of v to m_2 assuming a perfectly elastic impact. Then, the ratio $\frac{m_1}{m_2}$ is

(a) 5 (b) 1/5
(c) 1/25 (d) 25

TS-EAMCET.14.09.2020, Shift-2

@apna_pdf

Ans. (a) :



Law of conservation of momentum

$$m_1u = m_1\frac{2}{3}u + m_2v$$

$$m_1u - \frac{2}{3}m_1u = m_2v$$

$$\frac{1}{3}m_1u = m_2v \quad \text{.....(i)}$$

According to the Newton's law of restitution

$$e = 1 = \frac{v_{separation}}{v_{approach}}$$

$$1 = \frac{v - \frac{2u}{3}}{u}$$

$$v - \frac{2u}{3} = u$$

$$3v - 2u = 3u$$

$$3v = 5u$$

$$v = \frac{5}{3}u$$

Putting the value of v in equation (i), we get –

$$\frac{1}{3}m_1u = \frac{5}{3}m_2u$$

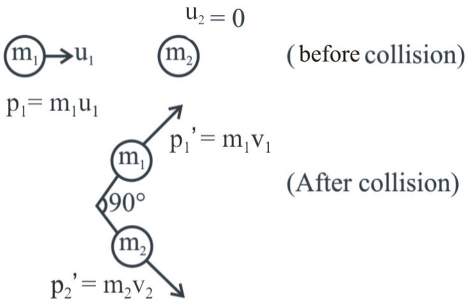
$$\frac{m_1}{m_2} = 5$$

510. A particle of mass m_1 collides with a particle of mass m_2 at rest. After the elastic collision, the two particles moves at an angle of 90° with respect to each other. The ratio $\frac{m_2}{m_1}$ is

(a) 1.0 (b) 1.5
(c) 2.0 (d) 2.5

TS-EAMCET-09.09.2020, Shift-1

Ans. (a) : According to given condition –



According to conservation of momentum –

$$p_1 = p'_1 + p'_2 \quad \text{.... (i)}$$

K.E. conservation given

$$\frac{p_1^2}{m_1} = \frac{p_1'^2}{m_1} + \frac{p_2'^2}{m_2} \quad \text{.....(ii)} \quad \left[K = \frac{p^2}{2m}\right]$$

Putting the value of p_1 in equation (ii), we get –

$$\frac{p_1'^2}{m_1} + \frac{p_2'^2}{m_2} = \frac{1}{m_1}\left(p_1' + p_2'\right)^2$$

$$\frac{p_1'^2}{m_1} + \frac{p_2'^2}{m_2} = \frac{p_1'^2}{m_1} + \frac{p_2'^2}{m_1} + \frac{2(p_1' \cdot p_2')}{m_1}$$

$$\frac{p_2'^2}{m_2} = \frac{p_2'^2}{m_1} + \frac{2(p_1' \cdot p_2')}{m_1} \quad \text{....(iii)}$$

Particles moves at an angle 90° after collision

$$\vec{p}_1' \cdot \vec{p}_2' = p_1'\, p_2' \cos\theta$$

$$\vec{p}_1' \cdot \vec{p}_2 = p_1'\, p_2' \cos 90°$$

$$\vec{p}_1' \cdot \vec{p}_2 = 0$$

Putting the value of $p_1'\, p_2'$ in equation (iii), we get –

$$\frac{p_2'^2}{m_2} = \frac{p_2'^2}{m_1}$$

$$\frac{m_2}{m_1} = \frac{p_2'^2}{p_2'^2}$$

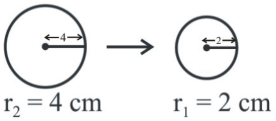
$$\frac{m_2}{m_1} = 1$$

511. A steel ball of radius 2 cm is at rest on a frictionless surface. Another steel ball of radius 4 cm moving with velocity of 81 cms^{-1} collides elastically with the ball which is at rest. After collision the ball with radius of 2 cm moves with speed of

(a) 144 cm s^{-1} (b) 72 cm s^{-1}
(c) 216 cm s^{-1} (d) 36 cm s^{-1}

AP EAMCET (22.09.2020) Shift-I

Ans. (a) : Given, $u_1 = 81$ cm/s, $u_2 = 0$



Mass of balls $(m_1) = (\text{volume})_1 \times d$

$$m_1 = \frac{4}{3}\pi r_1^3 d$$

From, $m_2 = v_2 \times d$

$$m_2 = \frac{4}{3}\pi r_2^3 d$$

In case of elastic collision

$$u_1m_2 = m_1v_1 + m_2v_2$$

$$\frac{4}{3}\pi r_2^3 d.81 = \frac{4}{3}\pi r_1^3.d.v_1 + \frac{4}{3}\pi r_2^3.d.v_2$$

$$v_1 + 8v_2 = 8 \times 81 \quad \text{...(1)}$$

Again coefficient of restitution

$$e = \frac{v_2 - v_1}{0 - 81} = 1$$

$$v_1 - v_2 = 81 \quad \text{.......(ii)}$$

@apna_pdf

From equation (i) and (ii), we get

$$9v_2 = 7 \times 81$$
$$v_2 = 7 \times 9$$
$$v_2 = 63 \text{ cm/s}$$

Putting the value of v_2 in equation (ii), we get–

$$v_1 - 63 = 81$$
$$v_1 = 144 \text{ cm/s}$$

512. Two balls X (2 kg) and Y (4 kg) approach each other with equal speeds of $10\text{ms}^{-1.}$ If the collision is perfectly elastic, then the new velocities of balls X and Y are respectively

(a) $\frac{50}{3}\text{ms}^{-1}, -\frac{10}{3}\text{ms}^{-1}$

(b) $-\frac{50}{3}\text{ms}^{-1}, -\frac{10}{3}\text{ms}^{-1}$

(c) $-\frac{50}{3}\text{ms}^{-1}, \frac{10}{3}\text{ms}^{-1}$

(d) $\frac{50}{3}\text{ms}^{-1}, \frac{10}{3}\text{ms}^{-1}$

AP EAMCET (21.09.2020) Shift-I

Ans. (c) : Given, $m_1 = 2\text{kg}$, $m_2 = 4\text{kg}$, $v_1 = v_2 = 10$ m/s

Kinetic energy as well momentum will be conserved in perfectly elastic collision.

By the conservation of momentum,

$$m_1 \times 10 + m_2 \times (-10) = m_1v_1 + m_2v_2$$
$$2 \times 10 + 4 \times (-10) = 2v_1 + 4v_2$$
$$-20 = 2(v_1 + 2v_2)$$
$$v_1 + 2v_2 = -10 \qquad \text{.....(i)}$$

In perfect collision–

$$v_2 - v_1 = 10 - (-10)$$
$$v_2 - v_1 = 20 \qquad \text{.....(ii)}$$

Adding equation (i) and equation (ii)

$$3v_2 = 10$$
$$v_2 = {}^{10}\!/_{3} \text{ m/s}$$

Putting the value of v_2 in equation (ii), we get–

$$\frac{10}{3} - v_1 = 20$$
$$-v_1 = 20 - \frac{10}{3}$$
$$v_1 = \frac{-50}{3} \text{m/s}$$

Hence, velocities of balls x and y respectively are $-{}^{50}\!/_{3}$ m/s and ${}^{10}\!/_{3}$ m/s.

513. A bullet strikes against a wooden block and is embedded in it, the nature of collision is

(a) Elastic
(b) Perfectly inelastic
(c) Inelastic
(d) Perfectly elastic

AP EAMCET (18.09.2020) Shift-II

Ans. (b) : When a bullet strikes a wooden block and embedded in it, then such type of collision is an example of perfectly inelastic collision. In this type of collision, maximum loss of kinetic energy occurs.

In any type of collision total linear momentum of system always remain conserved.

514. When two bodies collide elastically, then

(a) Kinetic energy of the system along is conserved
(b) Only momentum is conserved
(c) Both kinetic energy and momentum is conserved
(d) Neither kinetic energy nor momentum is conserved

AP EAMCET (18.09.2020) Shift-I

Ans. (c) : In case of elastic collision both the kinetic energy and momentum energy is conserved.

As the collision is elastic so there will not be any deformation in the shapes of the bodies so there will not be any loss in energy so the energy will remain constant.

515. An object flying in air with velocity $(20\hat{i} + 25\hat{j} - 12\hat{k})$ suddenly breaks in two pieces whose masses are in the ratio 1:5. The smaller mass flies off with a velocity $(100\hat{i} + 35\hat{j} + 8\hat{k})$. The velocity of the larger piece will be

(a) $4\hat{i} + 23\hat{j} - 16\hat{k}$

(b) $-100\hat{i} - 35\hat{j} - 8\hat{k}$

(c) $20\hat{i} + 15\hat{j} - 80\hat{k}$

(d) $-20\hat{i} - 15\hat{j} - 80\hat{k}$

NEET (Odisha) - 2019

Ans. (a) : Let mass of smaller piece is m

So, mass of bigger piece is 5 m

As we know that during explosion there is no external force on it,

So, we can use momentum conservation

Initial momentum = final momentum

$$(m+5m)\ (20\hat{i} + 25\hat{j} - 12\hat{k}) = m(100\hat{i} + 35\hat{j} + 8\hat{k}) + 5mv$$
$$6m(20\hat{i} + 25\hat{j} - 12\hat{k}) = m(100\hat{i} + 35\hat{j} + 8\hat{k}) + 5mv$$
$$6(20\hat{i} + 25\hat{j} - 12\hat{k}) = (100\hat{i} + 35\hat{j} + 8\hat{k}) + 5v$$
$$(120\hat{i} + 150\hat{j} - 72\hat{k}) - (100\hat{i} + 35\hat{j} + 8\hat{k}) = 5v$$
$$120\hat{i} + 150\hat{j} - 72k - 100\hat{i} - 35\hat{j} - 8\hat{k} = 5v$$
$$5v = 20\hat{i} + 115\hat{j} - 80\hat{k}$$
$$\therefore \qquad v = 4\hat{i} + 23\hat{j} - 16\hat{k}$$

516. Body A of mass 4m moving with speed u collides with another body B of mass 2 m, at rest. The collision is head on and elastic in nature. After the collision the fraction of energy lost by the colliding body A is

(a) $\frac{8}{9}$
(b) $\frac{4}{9}$
(c) $\frac{5}{9}$
(d) $\frac{1}{9}$

NEET (National) - 2019

@apna_pdf

Ans. (a) : Given,

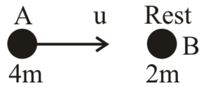
Mass of body A (m_1) = 4m

Speed of collide body A (u_1) = u

Mass of body B (m_2) = 2m

Speed of rest body B (u_2) = 0

Energy transferred to B initial energy of B = 0 final velocity



$$v_B = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2 + \frac{2m_1 u_1}{m_1 + m_2}$$

$$v_B = \left(\frac{2m - 4m}{4m + 2m}\right) \times 0 + \frac{2 \times 4m \times u}{4m + 2m}$$

$$v_B = \frac{2(4m)u}{6m} = \frac{4}{3}u$$

$$\frac{\frac{1}{2}m_2 v_B^2}{\frac{1}{2}m_1 u_1^2} = \frac{\frac{1}{2} \times 2m\left(\frac{4}{3}\right)^2 u^2}{\frac{1}{2} \times 4mu^2}$$

$$\text{Fraction of energy lost} = \frac{8}{9}$$

517. A toy truck of mass 2m elastically collides with a toy car of mass m. speed of truck is v and car is at rest. Find the velocity of car after collision.

(a) $\frac{4v}{3}$ (b) $\frac{v}{3}$

(c) v (d) $\frac{2v}{3}$

JIPMER-2019

Ans. (a) : Given, mass of toy truck (m_1) = 2m, mass of toy car (m_2) = m, before collision speed of truck (u_1) = v, before collision speed of car (u_2) = 0, collision is elastic (e) = 1

According to conservation of linear momentum-

$p_i = p_f$

$2mv + 0 = 2mv_1 + mv_2$ ....(i)

$\because \quad e = \frac{v_2 - v_1}{u_1 - u_2}$

$1 = \frac{v_2 - v_1}{v - 0}$

$v_2 - v_1 = v$

$v_1 = v_2 - v$ ....(ii)

Putting the value of v_1 in equation (i), we get –

$2mv = 2m(v_2 - v) + mv_2$

$2mv = 2mv_2 - 2mv + mv_2$

$4mv = 3mv_2$

$v_2 = \frac{4}{3}v$ m/s

518. A body dropped from a height 'h' reaches the ground with a speed $\sqrt{gh}$. The work done by the air friction is

(a) – mgh (b) – 0.5 mgh

(c) – 0.25 mgh (d) – 0.125 mgh

Assam CEE-2019

Ans. (b) : Given, $v = \sqrt{gh}$

Work done by air friction = $(K.E)_{final} - (U)_{initial}$

$$\text{Work done by air friction} = \frac{1}{2}mv^2 - mgh$$

$$= \frac{1}{2}m(\sqrt{gh})^2 - mgh$$

$$= -mgh/2$$

Work done by air friction = – 0.5 mgh

519. A bullet of mass 'm' hits a target of mass 'M' hung to a string and gets embedded in it. If the block with embedded bullet swings and rises to a height 'h' as a result of this inelastic collision, the velocity of the bullet before collision is

(a) $\sqrt{(M+m)gh}$ (b) $\left(\frac{M+m}{m}\right)\sqrt{2gh}$

(c) $\left(\frac{M+m}{m}\right)2gh$ (d) $(m+M)gh$

MHT-CET 2019

Ans. (b) : Given- mass of bullet = m

Target mass = M

Let initial velocity is v and combined velocity is v′.

From conservation of momentum–

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$mv + M\times 0 = v'(M+m)$

$v' = \frac{mv}{(M+m)}$ .....(i)

From third equation of motion

$v^2 = u^2 + 2gh$

$v'^2 = 2gh$ (initial velocity of block is 0)

or $v' = \sqrt{2gh}$ .....(ii)

On solving equation (i) and (ii), we get –

$$\sqrt{2gh} = \frac{mv}{(M+m)}$$

$$v = \left(\frac{M+m}{m}\right)\sqrt{2gh}$$

520. A block of mass m moving with a velocity v. collides with another block of mass 4m at rest. The lighter block comes to rest after collision Find the coefficient of restitution

(a) 4 (b) 0.25

(c) 0.2 (d) 2

J&K-CET-2019

Ans. (b) :

m
v
4m
at rest
Before collision
m
at rest
4m
v'
After collision

According to law of conservation of linear momentum,

$P_i = P_f$

$m(v) + 4m(0) = m(0) + 4m(v')$

@apna_pdf

$$mv = 4mv'$$

$$v' = \frac{v}{4}$$

Then,

$$e = \frac{\text{velocity of seperation}}{\text{velocity of approach}}$$

$$e = \frac{\left(\frac{v}{4}\right)}{v} = \frac{1}{4} = 0.25$$

521. During inelastic collision between two objects, which of the following quantity always remains conserved ?

(a) Total kinetic energy
(b) Total mechanical energy
(c) Total linear momentum
(d) Speed of each body

Karnataka CET-2019

Ans. (c) : During inelastic collision total linear momentum is conserved but total kinetic energy and total mechanical energy is not conserved. This lack of conservation means that the forces between colliding objects may converts kinetic energy to other forms of energy, such as potential energy or thermal energy.

522. Body A of mass 4 m moving with speed u collides with another body B of mass 2 m at rest the collision is head on and elastic in nature. After the collision the fraction of kinetic energy lost by colliding body A is:

(a) $\frac{5}{9}$ (b) $\frac{1}{9}$
(c) $\frac{8}{9}$ (d) $\frac{4}{9}$

AIIMS-25.05.2019(M) Shift-1

Ans. (c) : Given that,

$$m_1 = 4m,\ u_1 = u : m_2 = 2m,\ u_2 = 0$$

$$v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{(m_1 + m_2)}$$

$$v_1 = \frac{2m(u) + 0}{6m} = \frac{u}{3}$$

$$v_2 = \frac{(m_1 - m_2)u_2 + 2m_1u_1}{(m_1 + m_2)}$$

$$v_2 = \frac{0 + 2 \times 4mu}{6m} = \frac{4u}{3}$$

So, initial kinetic energy of body A = $\frac{1}{2}(4m)\,u^2$

Final kinetic energy body of A = $\frac{1}{2}(4m)\frac{u^2}{9}$

Fraction of K.E. lost by fraction

$$\frac{\Delta KE}{KE_i} = \frac{\frac{1}{2}(4m)u^2 - \frac{1}{2}(4m)\frac{u^2}{9}}{\frac{1}{2}(4m)u^2} = \frac{8}{9}$$

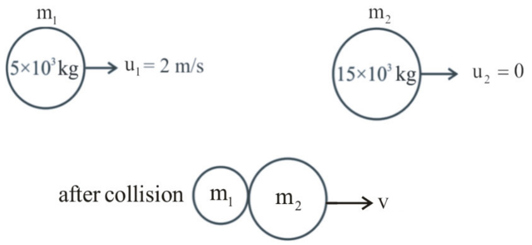
523. A body of mass 5×10^3 kg moving with speed 2 m/s collides with a body of mass 15×10^3 kg in-elastically & sticks to it. Then loss in K.E. of the system will be:

(a) 7.5 kJ (b) 15 kJ
(c) 10 kJ (d) 5 kJ

AIIMS-26.05.2019(E) Shift-2

Ans. (a) : Given,

$$m_1 = 5 \times 10^3\ \text{kg}$$
$$m_2 = 15 \times 10^3\ \text{kg}$$
$$u_1 = 2\ \text{m/s}$$



By conservation of momentum

$$m_1u_1 + m_2 \times 0 = (m_1 + m_2)\,v$$

$$v = \frac{m_1u_1}{m_1 + m_2}$$

$$\text{Loss in K.E.} = \frac{1}{2}m_1u_1^2 - \frac{1}{2}(m_1 + m_2)\left(\frac{m_1u_1}{m_1 + m_2}\right)^2$$

$$= \frac{1}{2}m_1u_1^2 - \frac{1}{2}\frac{(m_1u_1)^2}{m_1 + m_2}$$

$$= \frac{1}{2}m_1u_1\left(u_1 - \frac{m_1u_1}{(m_1 + m_2)}\right)$$

$$= = \frac{1}{2}m_1u_1\left(\frac{u_1(m_1 + m_2) - m_1u_1}{(m_1 + m_2)}\right)$$

$$= \frac{1}{2}m_1u_1\left(\frac{m_1u_1 + m_2u_1 - m_1u_1}{(m_1 + m_2)}\right)$$

$$= \frac{1}{2}m_1u_1 \times \frac{m_2u_1}{(m_1 + m_2)}$$

$$= \frac{m_1m_2u_1^2}{2(m_1 + m_2)}$$

$$= \frac{1}{2} \times \frac{5\times10^3 \times 15\times10^3 \times (2)^2}{(5\times10^3 + 15\times10^3)}$$

$$= \frac{1}{2} \times \frac{75\times10^3}{20} \times 4$$

$$= 7.5\ \text{kJ}$$

524. Assertion: There is no loss in energy in elastic collision

Reason: Linear momentum is conserved in elastic collision

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

@apna_pdf

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-25.05.2019(M) Shift-1

Ans. (b) : In elastic collision, energy and momentum are conserved, therefore no loss in energy occurs in elastic collision. Therefore both A and R are true but R is not the correct explanation of A.

525. Assertion: Rayleigh scattering can be considered as elastic collisions of photons with massive particles.
Reason: In Rayleigh scattering, the energy of incident and scattered is same
(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-25.05.2019(M) Shift-1

Ans. (a) : Rayleigh scattering is elastic scattering of electromagnetic radiation at particles, which are much smaller than the wavelength of the radiation. In Rayleigh scattering, when a photon collide with a very massive particles then the momentum transferred will be p or 2p so energy transferred is $\frac{p^2}{2m}$ which will be very small.

526. Assertion: Collision between two billiard's ball is inelastic.
Reason: Momentum remains conserved during the collision
(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

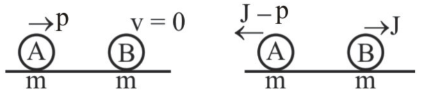
AIIMS-25.05.2019(M) Shift-1

Ans. (b) : Billiard's ball are not perfect elastic body. The commonly elastic collision seen between billiards balls because these balls do not compress Some part of initial kinetic energy is lost in form of deformation energy and momentum remains conserved during every collision.

527. A body a moving with momentum p collides one-dimensionally with another stationary body B of same mass. During impact, A gives impulse J to B. then which of the following is/are correct?
(i) The total momentum of A and B is p before and after impact and (p–J) during the impact
(ii) During the impact, B gives impulse of magnitude J to A.
(iii) The coefficient of restitution is $\left[\frac{2J}{p}-1\right]$.
(iv) The coefficient of restitution is $\left[\frac{2J}{p}+1\right]$.
(a) Only (i) is correct.
(b) (i) and (iii) are correct.
(c) (ii) and (iii) are correct.
(d) Only (iii) is correct.

AP EAMCET (23.04.2019) Shift-I

Ans. (c) : According to the question, collision between two bodies (A and B)



So, coefficient of restitution–

$$e=\frac{\text{Relative velocity of sepration}}{\text{Relative velocity of approach}}$$

$$e=\frac{\frac{J-p}{m}+\frac{J}{m}}{\frac{p}{m}-0}=\frac{2J}{p}-1 \qquad \left[\because v=\frac{mv}{m}=\frac{p}{m}\right]$$

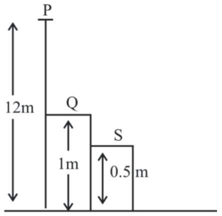
During the impact, B gives impulse–

$$J_B=p+J-p=J$$

528. A ball dropped from a building of height 12 m falls on a slab of 1 m height from the ground and makes a perfect elastic collision.
Later the ball falls on a wooden table of height 0.5 m, makes inelastic collision and falls on the ground. If the coefficient of restitution between the ball and the table is 0.5, then the velocity of the ball while touching the ground is about (Acceleration due to gravity, g = 10 ms^{-2})
(a) 15.5 ms^{-1} (b) 14.5 ms^{-1}
(c) 9.2 ms^{-1} (d) 8.2 ms^{-1}

AP EAMCET (22.04.2019) Shift-II

Ans. (d) :



Ball strike at point Q from dropping P point

$$v_1^2=u^2+2gh$$

$$v_1^2=0^2+2\times10\times(12-1)$$

$$v_1^2=220 \qquad \ldots(i)$$

$$v_1=\sqrt{220}\ m/s,$$

Velocity of ball at point Q = v_1

@apna_pdf

Height gain by ball after collision –

$$\frac{1}{2}mv_1^2 = mgh_1$$

$$\frac{1}{2}\left(\sqrt{220}\right)^2 = 10\times h_1 \qquad \left[\because v_1=\sqrt{220}\right]$$

$$h_1 = 11m$$

Ball will go up to 11m after mitigate point Q. Latter ball falls on a wooden table of height 0.5 m.

(As According to law) of energy conservation,

$$\frac{1}{2}mv_s^2 = mg(11+0.5)$$

$$v_s^2 = 2\times10\times11.5$$

$$v_s = \sqrt{23\times10}$$

$$v_s = \sqrt{230}\ m/s$$

Given,

Coefficient of restitution (e) = 0.5

$$\therefore \qquad e = \frac{\text{Velocity after collision}}{\text{velocity}(v_s)\text{ before collision}}$$

$$0.5 = \frac{v}{\sqrt{230}}$$

$$v = 0.5\sqrt{230}m/s$$

By energy conservation law –

$$\frac{1}{2}mv^2 = mgh_2$$

$$\frac{1}{2}\left(0.5\sqrt{230}\right)^2 = 10\times h_2$$

$$h_2 = \frac{0.5\times230\times0.5}{20}$$

$$h_2 = 2.875m$$

Total height gain by ball –

$$h = h_1 + h_2$$

$$h = 0.5 + 2.875$$

$$h = 3.375\ m$$

$$\therefore \quad \frac{1}{2}mv_T^2 = mgh \qquad \left[\begin{array}{l} v_T = \text{velocity of ball} \\ \text{while touching ground}\end{array}\right]$$

and

$$v_T = \sqrt{2gh}$$

$$v_T = \sqrt{2\times10\times3.375}$$

$$v_T = 8.215\ m/s$$

529. Two particles P and Q each of mass 3m lie at rest on the X-axis at points $(-\alpha, 0)$ and $(+\alpha, 0)$, respectively. A third particle R of mass 2 m initially at the origin moves towards the particle Q. If all the collisions of the system of 3 particles are elastic and head on, the total number of collisions in the system is

(a) 2 (b) 3

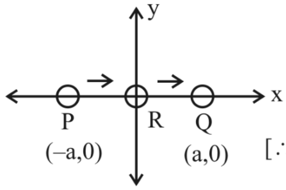
(c) 4 (d) 5

AP EAMCET (20.04.2019) Shift-1

Ans. (a) : According to question ball are located in salvation.

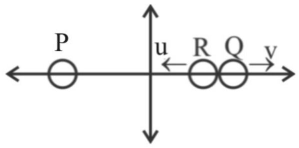
Mass of P = Mass of Q = 3m

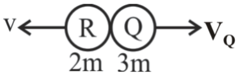
Mass of R = 2m



[∴ R is located in center]

Let initial velocity of R = u

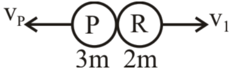




As Conservation of momentum

$$2mu = -2mv + 3mv_Q$$

$$v < u,\ v < v_Q$$



Collision between P and R

$$-2mv = 2mv_1 - 3mv_P$$

$$v_1 < v,\ v_1 < v_P$$

$$v_1 < v_Q \qquad (\because \text{Never collide})$$

Hence, R will not meet to Q after collision with P. Hence only 2 collision will happen.

530. A ball of mass 150 g, moving with an acceleration 20 m/s^2, is hit by a force, which acts on it for 0.1 sec. The impulsive force is

(a) 0.5 N-s (b) 0.1 N-s

(c) 0.3 N-s (d) 1.2 N-s

BITSAT-2019

Ans. (c) : Given,

$$\text{Mass of ball (m)} = 150g = \frac{150}{1000}kg = \frac{15}{100}kg$$

Acceleration (a) = 20m/s^2

Force acting on ball –

$$F = ma$$

$$F = \frac{15}{100}\times20$$

$$F = 3N$$

$$\therefore \text{Impulsive force} = F\times\Delta t \qquad [\because \Delta t = 0.1sec]$$

$$\text{Impulsive force} = 3\times0.1$$

$$\text{Impulse force} = 0.3\ N\text{-}s$$

531. A moving block having mass m, collides with another stationary block having mass 4m. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of restitution (e) will be

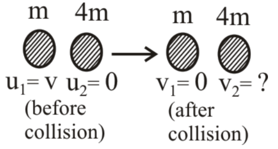
(a) 0.8 (b) 0.25

(c) 0.5 (d) 0.4

NEET- 2018

@apna_pdf

Ans. (b) : According to question-



Apply law of conservation of momentum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$mv + 4m\times0 = m\times0 + 4m\times v_2$$

$$mv = 4m\times v_2$$

$$\therefore\ v_2 = \frac{v}{4}$$

The value of coefficient of restitution (e) = $\frac{v_2 - v_1}{u_1 - u_2}$

$$e = \frac{\frac{v}{4} - 0}{v - 0} = \frac{1}{4}$$

$$e = \frac{1}{4}$$

$$e = 0.25$$

532. Which of the following is not conserved in inelastic collision?

(a) Momentum
(b) Kinetic energy
(c) Both momentum and kinetic energy
(d) Neither momentum nor kinetic energy

HP CET-2018

Ans. (b) : During inelastic collision kinetic energy does not remain same. Kinetic energy is not conserved in inelastic collision.

533. A ball of mass 2 kg collides with another ball of mass m at rest. If the collision is elastic and after the collision, the first ball moves with $\frac{1}{3}$ of its initial velocity in the same direction then the mass of second ball is

(a) 2.5 kg (b) 3.5 kg
(c) 3.0 kg (d) 1.0 kg

AP EAMCET-24.04.2018, Shift-II

Ans. (d) : Given, $m_1 = 2$ kg

Let initial velocity of first ball = u

Initial velocity of second ball = 0

Mass of second body (m_2) = m

and velocity of second body after collision = v

After collision, velocity of first ball = $\frac{u}{3}$

$$\therefore \qquad \frac{\frac{u}{3} - v}{u + 0} = -1 \qquad (\because \text{ collision is elastic } e = 1)$$

$$\frac{u}{3} - v = -u$$

$$u + \frac{u}{3} - v = 0$$

$$\frac{4u}{3} = v$$

or $\qquad v = \frac{4u}{3} \qquad \ldots. (i)$

Now conservation of momentum,

$$m_1u + 0 = \frac{m_1u}{3} + mv$$

$$m_1u - \frac{m_1u}{3} = mv$$

$$\frac{2m_1u}{3} = mv$$

Putting the value of v from equation (i), we get

$$\frac{2m_1u}{3} = \frac{m \times 4u}{3}$$

$$\frac{2\times2}{3} = m\times\frac{4}{3} \qquad (m_1 = 2\text{kg})$$

$$m = 1\text{kg}$$

534. Assertion (A) : In analysing the problems of inelastic collisions the law of conservation of momentum and the law of conservation of mechanical energy are to be employed

Reason (R) : Since the laws of conservation of momentum and mechanical energy are fundamental laws. They should hold good in any situation.

Which of the following is true?

(a) The (A) is correct but the (R) is incorrect
(b) Both (A) and (R) are correct and (R) is the correct explanation of the (A)
(c) Both (A) and (R) are correct but the (R) is not the correct explanation of the (A)
(d) Both (A) and (R) are incorrect

TS EAMCET 02.05.2018, Shift-II

Ans. (d) : Inelastic collision :- An inelastic collision is such a type of collision that takes place between two objects in which some energy is lost. In the case of inelastic collision, momentum is conserved but the mechanical energy is not conserved because of internal friction.

Thus, conservation of mechanical energy is not employed in the problem of inelastic collision.

535. A hardboiled egg (H) and a raw egg (R) are both spun on a flat table. They are stopped momentarily and released immediately. Which of the following statements is correct?

(a) (H) remains stationary whereas the (R) starts spinning again
(b) (H) spins again whereas (R) comes to a stop
(c) Both (H) and (R) come to a stop
(d) Both (H) and (R) spin again

TS EAMCET 02.05.2018, Shift-II

Ans. (a) : Hard egg remains stationary whereas the raw egg starts spinning again when they are released immediately after stopped momentarily because the hard egg acts just like a rigid body while raw egg contains liquid material in it.

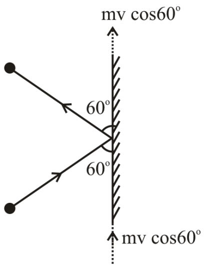
@apna_pdf

536. A 3 kg steel ball hits a concrete wall with a speed of 10m/s at an angle of 60^o with the surface and bounces off with the same speed and angle. The average force exerted by the ball on the wall if the ball is in contact with the wall for 0.2 s. is

(a) 2.6×10^2N (b) 52 N
(c) 1.3×10^2N (d) 5.2 N

TS EAMCET 03.05.2018, Shift-I

Ans. (a) :



Change in momentum along the wall will be zero.

∵ $mv\cos 60^o - mv\cos 60^o = 0$

Now,

Change in the momentum perpendicular to the wall

$= mv\sin 60^o - (-mv\sin 60^o)$
$= 2mv\sin 60^o$

∴ Force exerted by the ball on wall

$$= \frac{\text{Change in mometnum}}{\text{Time}}$$

$$= \frac{2mv\sin 60^o}{0.20}$$

$$= \frac{2 \times 3 \times 10 \times \sqrt{3}}{2 \times 0.20} = 50 \times 3\sqrt{3}$$

$= 2.6 \times 10^2$ N

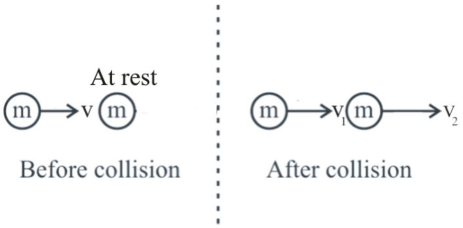
537. A sphere of mass 'm' moving with velocity 'v' collides head-on on another sphere of same mass which is at rest. The ratio of final velocity of second sphere to the initial velocity of the first sphere is (e is coefficient of restitution and collision in inelastic)

(a) $\frac{e-1}{2}$ (b) $\frac{e}{2}$
(c) $\frac{e+1}{2}$ (d) e

MHT-CET 2018

Ans. (c) : Given, mass of sphere = m

According to the question, we can draw following figure :



Applying the conservation law of momentum,

$mv + m(0) = mv_1 + mv_2$
$mv = mv_1 + mv_2$
$mv = m(v_1 + v_2)$
$v = v_1 + v_2$
$v_1 = v - v_2$ ...(i)

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

$$e = \frac{v_2 - v_1}{v - 0}$$

$ev = v_2 - v_1$

From equation (i), we get –

$ev = v_2 - (v - v_2)$
$ev = v_2 - v + v_2$
$ev = 2v_2 - v$
$ev + v = 2v_2$
$v(1+e) = 2v_2$

$$\frac{v_2}{v} = \left(\frac{e+1}{2}\right)$$

Hence, the ratio of final velocity of second sphere to the initial velocity of first sphere is $\left(\frac{e+1}{2}\right)$.

538. The principle of conservation of linear momentum can be strictly applied during a collision between two particles provided the time of impact

(a) is extremely small
(b) is moderately small
(c) is extremely large
(d) depends on particular case

VITEEE-2018

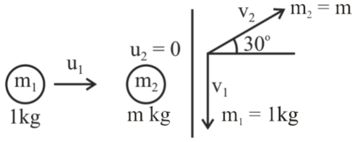
Ans. (a) : The principle of conservation of linear momentum can be strictly applied during a collision between two particles provided the time of impact is extremely small.

539. A ball of mass 1 kg moving along x-direction collides elastically with a stationary ball of mass m. The first ball (mass = 1 kg) recoils at right angle to its original direction of motion. If the second ball starts moving at an angle 30^o with the X-axis, then the value of m must be

(a) 0.5 kg (b) 1.5 kg
(c) 2.5 kg (d) 2 kg

TS-EAMCET-04.05.2018, Shift-1

Ans. (d) : Given, $m_1 = 1$ kg, $m_2 = m$ kg



Law of conservation of momentum along x-axis –

$m_1u_1 = m_2v_2\cos 30^o$ (x-axis)

$$1 \times u_1 = \frac{m\sqrt{3}}{2}v_2$$

$$u_1 = \frac{\sqrt{3}}{2}mv_2 \quad \text{....(i)}$$

@apna_pdf

$m_1v_1 = m_2v_2 \sin30^o$ (at y-axis)

$$1\times v_1 = mv_2\times\frac{1}{2}$$

$$v_1 = \frac{1}{2}mv_2 \qquad ....(ii)$$

According to conservation of energy

$$\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_1v_1^2+\frac{1}{2}m_2v_2^2$$

$$\frac{1}{2}u_1^2\times1 = \frac{1}{2}v_1^2\times1+\frac{1}{2}mv_2^2$$

$$\frac{1}{2}u_1^2 = \frac{1}{2}\left(v_1^2+mv_2^2\right)$$

$$u_1^2 = v_1^2+mv_2^2$$

$$u_1^2-v_1^2 = mv_2^2 \qquad ....(iii)$$

Putting the value of u_1 and v_1 in equation (iii), we get –

$$\left(\frac{\sqrt{3}}{2}\right)^2 m^2v_2^2-\left(\frac{1}{2}\right)^2 m^2v_2^2 = mv_2^2$$

$$\frac{3}{4}m^2v_2^2-\frac{1}{4}m^2v_2^2 = mv_2^2$$

$$mv_2^2\left[\frac{3}{4}m-\frac{1}{4}m\right] = mv_2^2$$

$$\frac{3}{4}m-\frac{1}{4}m = 1$$

$$m\left(\frac{1}{2}\right) = 1$$

$$m = 2\text{kg}$$

540. **Assertion** (A) When we bounce a ball on the ground, it comes to rest after a few bounces, losing all its energy. This is an example of violation of conservation of energy.

Reason (R) Energy can change from one form to another but the total energy is always conserved.

Which of the following is true?

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true, but (R) is not the correct explanation of (A)

(c) (A) is true, but (R) is false

(d) (A) is false, but (R) is true

TS-EAMCET-04.05.2018, Shift-1

Ans. (d) : Bounce ball is a example of conservation of energy. It is a Universal law. It is not violation law of conservation of energy.

The law of conservation of energy states that energy can change forms, but is neither created nor destroyed.

Hence, Assertion is incorrect and Reason is true.

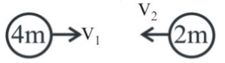
541. A block of mass 4 m travelling at a velocity v_1 in x-direction on a frictionless horizontal plane makes a head-on collision with another block of mass 2 m travelling in opposite direction with a velocity v_2. After collision, both the blocks travel as a single block along x-direction with a final velocity $5v_2$. The ratio of velocities $\frac{v_1}{v_2}$ is

(a) 2 (b) 3

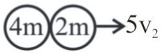
(c) 5 (d) 8

TS-EAMCET-05.05.2018, Shift-1

Ans. (d) : Given, mass of both block = 4m and 2m, velocity in x-direction = v_1, opposite direction velocity = v_2, final velocity = $5v_2$



(before collision)



(After collision)

Momentum before collision –

$$p_1 = 4mv_1 - 2mv_2 \qquad ..... (i)$$

Momentum after collision –

$$p_2 = 6m\,(5v_2) = 30mv_2 \qquad ..... (ii)$$

By conservation of momentum –

$$p_1 = p_2$$

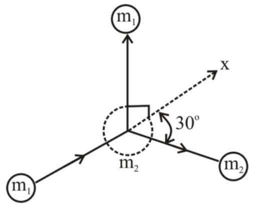
Putting the value of p_1 and p_2, we get –

$$4mv_1 - 2mv_2 = 30\,mv_2$$

$$4v_1 = 32v_2$$

$$\frac{v_1}{v_2} = \frac{32}{4} = 8$$

542. A particle of mass m_1 moving along the X-axis collides with a stationary particle of mass m_2 and deviates by an angle 30^o to the X-axis as shown in the figure. If the percentage change in kinetic energy of the combined system of these two particles reduces by 50%, then the ratio of the masses $\frac{m_2}{m_1}$ is

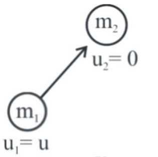


(a) 8 (b) 6

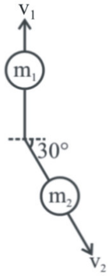
(c) $\frac{8}{7}$ (d) $\frac{1}{6}$

TS-EAMCET-05.05.2018, Shift-1

Ans. (a) :



(before collision)



(after collision)

@apna_pdf

Let velocity of m_1 and m_2 after collision are v_1 and v_2 respectively

Momentum conserve in both x and y direction

Along x-axis –

$$m_1u = m_2v_2 \cos 30°$$

$$m_1u = m_2v_2\frac{\sqrt{3}}{2} \qquad .....(i)$$

Along y-axis

$$0 = m_1v_1 - m_2v_2\sin30^o$$

$$m_1v_1 = m_2v_2 \sin 30°$$

$$m_1v_1 = \frac{m_2v_2}{2} \qquad .....(ii)$$

Loss of kinetic energy = 50%

$$\frac{K.E_i - K.E_f}{K.E_i} = \frac{1}{2}$$

So,

$$\frac{1}{2} = \frac{\frac{1}{2}m_1u^2 - \frac{1}{2}m_1v_1^2 - \frac{1}{2}m_2v_2^2}{\frac{1}{2}m_1u^2}$$

$$\frac{1}{2} = \frac{\frac{1}{2}\left[m_1u^2 - m_1v_1^2 - m_2v_2^2\right]}{\frac{1}{2}m_1u^2}$$

$$m_1u^2 - m_1v_1^2 - m_2v_2^2 = \frac{m_1u^2}{2}$$

$$m_1u^2 - \frac{m_1u^2}{2} = m_1v_1^2 + m_2v_2^2$$

$$\frac{m_1u^2}{2} = m_1v_1^2 + m_2v_2^2 \qquad .....(iii)$$

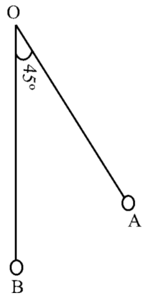
From equation (i) putting value of u and from (ii) value of v_1 in equation (iii), we get –

$$\frac{m_1}{2}\left(\frac{m_2}{m_1}\times\frac{v_2}{2}\sqrt{3}\right)^2 = m_1\left(\frac{m_2}{m_1}\times\frac{v_2}{2}\right)^2 + m_2v_2^2$$

$$\frac{3}{8}\times\frac{m_2^2}{m_1} = \frac{m_2^2}{4m_1} + m_2$$

$$\frac{m_2}{8m_1} = 1, \quad \frac{m_2}{m_1} = 8$$

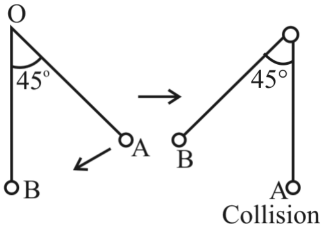
543. The bob A of a simple pendulum is released when the string makes an angle of 45° with the vertical. It hits another bob B of the same material and same mass kept at rest on the table. If the collision is elastic



(a) both A and B rise to the same height
(b) both A and B come to rest at B
(c) both A and B move with the same velocity of A
(d) A comes to rest and B moves with the velocity of A

Manipal UGET-2018

Ans. (d) : Masses of both object are same.



As bob is of same mass and in elastic collision their velocity are exchanged bob A comes to rest and B moves with velocity A.

The collision is elastic so, e = 1

$$e = \frac{\text{Speed of separation}}{\text{Speed of approach}} = \frac{v_2 - v_1}{u_1} = 1$$

$$v_2 - v_1 = u_1 \qquad .... (i)$$

From conservation of momentum –

$$mu_1 = mv_1 + mv_2$$

$$v_2 + v_1 = u_1 \qquad .....(ii)$$

By equation (i) and (ii), we get –

$$v_1 = 0 \ \& \ v_2 = u_1$$

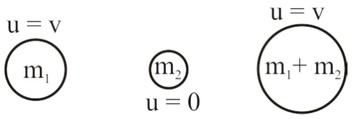
544. A particle of mass m_1 moving with velocity v collides with a mass m_2 at rest, then they get embedded. Just after collision, velocity of the system

(a) increases
(b) decreases
(c) remains constant
(d) becomes zero

BITSAT-2018

Ans. (b) : Let velocity after collision = v_1

By conservation of momentum



$$m_1v + m_2 \times 0 = (m_1 + m_2)\, v_1 \qquad [\because\ u_2 = 0]$$

$$v_1 = \frac{m_1}{m_1 + m_2}v$$

As $m_1 < (m_1 + m_2)$

$$\frac{m_1}{m_1 + m_2} < 1$$

So, $\quad v > v_1$

Therefore, velocity decrease at time of collision

545. Two spheres 'A' and 'B' of equal mass lie at rest at the opposite ends of a diameter of a smooth horizontal circular groove of radius 'r'. 'A' moves and collides with 'B' after a time 't'. If 'e' is the coefficient of restitution, next collision between the spheres takes place after a time of ______.

@apna_pdf

(a) $\frac{2t}{e}$ (b) t/e

(c) $\frac{\pi t}{e}$ (d) $\frac{2\pi t}{e}$

AP EAMCET-25.04.2017, Shift-II

Ans. (a) : The time taken for covering distance depends on the relative velocities between the bodies.

Now, as per question,

$$\pi r = tu$$

From the coefficient of restitution (e) = $\frac{(v_2 - v_1)}{u}$

$$(v_2 - v_1) = ue$$

Time required $= \frac{2\pi r}{v_2 - v_1} = \frac{2tu}{ue} = \frac{2t}{e}$

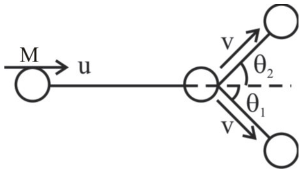
546. A billiard ball of mass ' M', moving with velocity 'v_1' collides with another ball of the same mass but at rest. If the collision is elastic the angle of divergence after the collision is

(a) 0^o (b) 30^o

(c) 90^o (d) 45^o

TS EAMCET (Engg.)-2017

Ans. (a, c) : When the collision is head-on then the angle of diversion is zero



According to law of conservation of momentum in the direction of initial velocity,

$$Mu = Mv(\cos\theta_1 + \cos\theta_2) \text{ .... (i)}$$

According to law of conservation of momentum in the perpendicular direction of initial velocity

$0 = Mv \sin\theta_1 - Mv \sin\theta_2 \Rightarrow \theta_1 = \theta_2$

∴ from equation (i),

$Mu = 2Mv \cos\theta$ $\quad [\because \theta_1 = \theta_2 = \theta]$

$$\cos\theta = \frac{u}{2v} \quad \text{..... (ii)}$$

According to law of conservation of K.E

$$\frac{1}{2}Mu^2 = \frac{1}{2}Mv^2 + \frac{1}{2}Mv^2$$

$$\Rightarrow \quad u^2 = 2v^2 \Rightarrow u = \sqrt{2}\,v \quad \text{.... (iii)}$$

Now from equation (ii)

$$\cos\theta = \frac{u}{2v} = \frac{\sqrt{2}\,v}{2v} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \quad \theta = 45°$$

Hence the angle of divergence = $\theta_1 + \theta_2 = 45^o + 45^o = 90^o$

547. A particle of mass m moving in the x direction with speed 2v is hit by another particle of mass 2m moving in the y direction with speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

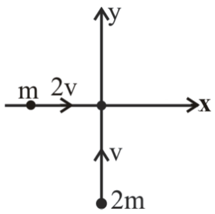
(a) 56% (b) 62%

(c) 44% (d) 50%

BITSAT-2017

Ans. (a) : Mass $m_1 = m$, $\quad m_2 = 2m$

$v_1 = 2v\hat{i} \quad v_2 = v\hat{j}$



Initial momentum $= m \times 2v\hat{i} + 2m \times v\hat{j}$

$$= \sqrt{(m \times 2v)^2 + (2m \times v)^2}$$

$$= 2\sqrt{2}\,mv$$

Final moment of the system = $3mv_{combined}$

By the law of conservation of momentum ,

$$2\sqrt{2}\,mv = 3mv_{combined}$$

$$v_{combined} = \frac{2\sqrt{2}v}{3}$$

Loss in energy,

$$\Delta E = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \frac{1}{2}(m_1 + m_2)v_{combined}^2$$

$$\Delta E = \frac{1}{2}m(2v)^2 + \frac{1}{2}2m(v)^2 - \frac{1}{2} \times 3m \times \left(\frac{2\sqrt{2}}{3}v\right)^2$$

$$\Delta E = 2mv^2 + mv^2 - \frac{4}{3}mv^2$$

$$\Delta E = 3mv^2 - \frac{4}{3}mv^2 = \frac{5}{3}mv^2$$

Percentage loss in energy,

$$\frac{\Delta E}{E} \times 100\% = \frac{\frac{5}{3}mv^2}{3mv^2} \times 100\%$$

$$= 55.55\% \approx 56\%$$

548. A body of mass 2m moving with velocity v makes a head on elastic collision with another body of mass m which is initially at rest. Loss of kinetic energy of the colliding body (mass 2m) is s

(a) 1/9 of its initial kinetic energy

(b) 1/6 of its initial kinetic energy

(c) 1/4 of its initial kinetic energy

(d) 1/2 of its initial kinetic energy

(e) 8/9 of its initial kinetic energy

Kerala CEE - 2017

Ans. (e) : Given,

$m_1 = 2m \quad m_2 = m$

$u_1 = v \quad u_2 = 0$

Final velocity of first body in collision

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

@apna_pdf

$$v_1 = \left(\frac{2m-m}{2m+m}\right)v + \left(\frac{2\times m}{2m+m}\right)\times 0$$

$$v_1 = \frac{m}{3m}v$$

$$v_1 = \frac{v}{3}$$

Kinetic energy after collision given

$$=\frac{1}{2}m\left(\frac{v}{3}\right)^2 = \frac{1}{2}m\left(\frac{v^2}{9}\right)$$

Change in kinetic energy-

$$=\frac{1}{2}m\left(v^2-\frac{v^2}{9}\right) = \frac{8}{9}\left(\frac{1}{2}mv^2\right)$$

$$=\frac{8}{9}\times \text{initial kinetic energy}$$

549. A ball is dropped from height h on the ground. If the coefficient of restitution is e, the height to which the ball goes up after it rebounds for the nth time is

(a) $\frac{h}{e^{2n}}$ (b) $\frac{e^{2n}}{h}$

(c) he^{2n} (d) he^n

UPSEE - 2015

Ans. (c) : Let, V_0 is the velocity of ball strikes first time from the ground, x = height to g which balls goes up after rebounds.

And V_n = after the n^{th} rebound

Coefficient of restitution

$$e = \frac{V_1}{V_0} = \frac{V_2}{V_1} = \frac{V_3}{V_2} = \frac{V_n}{V_{n-1}}$$

$$\therefore e^n = \frac{V_1}{V_0}\times\frac{V_2}{V_1}\times\frac{V_3}{V_2}\times.....\frac{V_n}{V_{n-1}} = \frac{V_n}{V_0} \quad ...(i)$$

As we know

$$V_0 = \sqrt{2gh}$$

$$V_n = \sqrt{2gx}$$

put these values in equation eq^n (i)

$$e^n = \sqrt{\frac{2gx}{2gh}} = \sqrt{\frac{x}{n}}$$

$$e^{2n} = \frac{x}{h} \Rightarrow \boxed{x = he^{2n}}$$

550. A ball is dropped from a height h. If the coefficient of restitution be e, then the body rebounds to a height of

(a) eh (b) e^2h

(c) e^3h (d) e^4h

BCECE-2008
UPSEE - 2010

Ans. (b) : Coefficient of restitution-

$$e = \sqrt{\frac{x}{h}} = \sqrt{\frac{2gx}{2gh}}$$

Where, h = drop height

x = Bounce height

$$e = \sqrt{\frac{x}{h}}$$

Squaring of both side, we get–

$$e^2 = \frac{x}{h}$$

$$x = e^2h$$

551. A bullet of mass 20 g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision?

(a) 200 m/s (b) 150 m/s

(c) 400 m/s (d) 300 m/s

UPSEE - 2006

Ans. (a) : Given, m_1 = 20 g = 0.02 kg, m_2 = 4kg, v = 600 m/s, h = 0.2 m

According to the law of conservation of linear momentum-

$$m_1v = m_1v_1 + m_2v_2$$

$$0.02\times600 = 0.02v_1+4v_2 \quad ......(i)$$

Here $v_2 = \sqrt{2gh} = \sqrt{2\times10\times0.2} = 2\,m/s$

Putting the value of v_2 in equation (i), we get–

$$0.02\times600 = 0.02\,v_1+4\times2$$

$$0.02v_1 = 12-8 = 4$$

$$v_1 = \frac{4}{0.02} = 200\,m/s$$

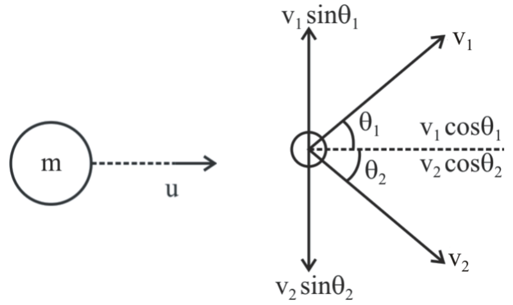
552. Consider elastic collision of a particle of mass m moving with a velocity u with another particle of the same mass at rest. After the collision the projectile and the struck particle move in directions making angles θ_1 and θ_2 respectively with the initial direction of motion. The sum of the angles $\theta_1 + \theta_2$, is :

(a) 45° (b) 90°

(c) 135° (d) 180°

BITSAT-2016
UPSEE - 2004

Ans. (b) : After collision both masses move in different direction



By the conservation of momentum in X-direction

$$p_{initial} = p_{final}$$

$$mu = mv_1\cos\theta_1 + mv_2\cos\theta_2$$

$$u = v_1\cos\theta_1 + v_2\cos\theta_2 \quad ....(i)$$

Similarly, conservation of momentum in y- direction

$$0 = v_1\sin\theta_1 - v_2\sin\theta_2 \quad ....(ii)$$

@apna_pdf

From conservation of energy–

$$K_i = K_f$$

$$\frac{1}{2}mu^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$$

$$u^2 = v_1^2 + v_2^2 \qquad \text{……..(iii)}$$

Squaring equation (i) and (ii) and then add

$$u^2 = v_1^2\cos^2\theta_1 + v_2^2\cos^2\theta_2 + 2v_1v_2\cos\theta_1 \times \cos\theta_2$$

$$+v_1^2\sin^2\theta_1 + v_2^2\sin^2\theta_2 - 2v_1v_2\sin\theta_1\sin\theta_2$$

$$u^2 = v_1^2 + v_2^2 + 2v_1v_2\{\cos\theta_1\cos\theta_2 - \sin\theta_1\sin\theta_2\}$$

$$u^2 = v_1^2 + v_2^2 + 2v_1v_2\cos(\theta_1 + \theta_2)$$

From equation (iii), we get–

$$u^2 = u^2 + 2v_1v_2\cos(\theta_1 + \theta_2)$$

$$2v_1v_2\cos(\theta_1 + \theta_2) = 0$$

$$2v_1v_2 \neq 0$$

$$\cos(\theta_1 + \theta_2) = 0 = \cos 90^o$$

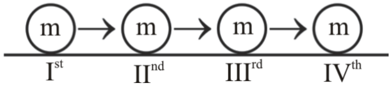
$$\theta_1 + \theta_2 = 90^o$$

553. Four smooth steel balls of equal mass at rest are free to move along a straight line without friction. The first ball is given a velocity of 0.4 m/s. It collides head on with the second elastically, the second one similarly with the third and so on. The velocity of the last ball is :

(a) 0.4 m/s (b) 0.2 m/s
(c) 0.1 m/s (d) 0.05 m/s

UPSEE - 2004

Ans. (a) : First ball velocity (v) = 0.4 m/s



From the law of conservation of momentum–

After 1st and 2nd ball collision $(v_1) = 0$

After 2nd and 3rd ball collision $(v_2) = 0$, $v_3 = v$

After 3rd and 4th ball collision $(v_3) = 0$, $v_4 = v$

Last ball will move with 0.4 m/s, $v_4 = 0.4$ m/s

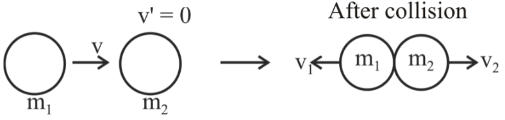
If masses of two bodies are equal then in the time of elastic collision velocity get interchanged.

554. A mass m_1 moves with a great velocity. It strikes another mass m_2 at rest in a head on collision. It comes back along its path with low speed, after collision. Then

(a) $m_1 > m_2$ (b) $m_1 < m_2$
(c) $m_1 = m_2$ (d) $m_1 \geq m_2$

BITSAT-2005

Ans. (b) :



Velocity of approach = Velocity of separation

$$v = v_2 + v_1$$

$$v_2 = v - v_1 \qquad \text{…..(i)}$$

Conservation of momentum –

$$m_1v = -m_1v_1 + m_2v_2$$

$$m_1v = -m_1v_1 + m_2(v - v_1) \qquad [\because v_2 = v - v_1]$$

$$m_1v = -m_1v_1 + m_2v - m_2v_1$$

$$m_1v + m_1v_1 = m_2v - m_2v_1$$

$$m_1(v + v_1) = m_2(v - v_1)$$

$$\frac{m_1}{m_2} = \frac{v - v_1}{v + v_1}$$

$$\because \frac{v - v_1}{v + v_1} < 1$$

$$\therefore \frac{m_1}{m_2} < 1$$

or $m_1 < m_2$

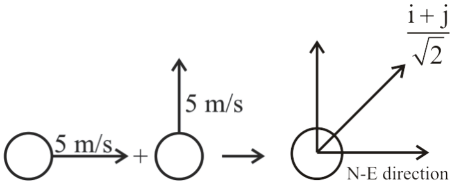
555. A particle of mass 10 kg moving eastwards with a speed 5 ms^{-1} collides with another particle of the same mass moving north-wards with the same speed 5 ms^{-1}. The two particles coalesce on collision. The new particle of mass 20 kg will move in the north-east direction with velocity

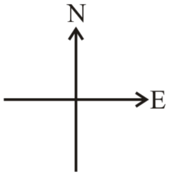
(a) 10 ms^{-1} (b) 5 ms^{-1}
(c) $(5/\sqrt{2})$ms^{-1} (d) None of these

BITSAT-2009

Ans. (c) : Mass of particle (m) = 10 kg

Speed of particle (v) = 5m/s





By conservation of momentum

$$10 \times 5\hat{i} + 10 \times 5\hat{j} = 20 \times v\left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right)$$

So, $$50(\hat{i} + \hat{j}) = 20 \times v\left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right)$$

$$v = \frac{50}{20} \times \sqrt{2}$$

$$v = \frac{5}{2} \times \sqrt{2} = \frac{5}{\sqrt{2}}$$

20 kg particle will move N-E direction,

$$v = \frac{5}{\sqrt{2}} m/s$$

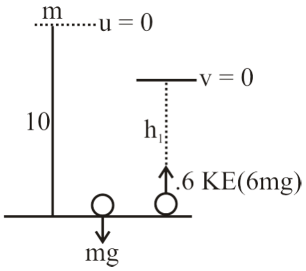
556. A ball is allowed to fall from a height of 10 m. If there is 40% loss of energy due to impact, then after one impact ball will go up to

(a) 10m (b) 8m
(c) 4m (d) 6m

BITSAT-2008

@apna_pdf

Ans. (d) : P.E + K.E = Constant



h = 10 m

h_1 = height after one impact.

Potential energy converted into kinetic energy –

$$mgh = \frac{1}{2}mv^2$$

$$mg \times 10 = \frac{1}{2}mv^2$$

10 mg = K.E

or K.E = 10 mg

After striking on ground, K.E will become 0.6 KE (due to loss of 40%) –

K.E = 0.6 × 10 mg

K.E = 6 mg

At h_1 height potential energy will equal to kinetic energy –

mgh_1 = 6 mg

h_1 = 6 meter

557. When two bodies stick together after collision, the collision is said to be

(a) partially elastic (b) elastic
(c) inelastic (d) perfectly inelastic

BITSAT-2007

Ans. (d) : When two collision bodies stuck together and move with a common velocity from the collision is said to be perfect inelastic. For perfect inelastic collision e = 0, In this collision total momentum of system conserve i.e. remain constant but kinetic energy is not conserved, is lost some part.

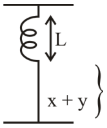
558 An elastic string of unstretched length L and force constant K is stretched by a small length x. It is further stretched by another small length y. The work done in the second stretching is

(a) $1/2\ Ky^2$ (b) $1/2\ Ky(2x + y)$
(c) $1/2\ K(x^2 + y^2)$ (d) $1/2\ K(x + y)$

BITSAT-2015

Ans. (b) : Initial stretching = $W = \frac{1}{2}Kx^2$

Final stretching = $W = \frac{1}{2}K(x+y)^2$



work done by elastic force of string (W) = $(U_f - U_i)$

$$= \frac{1}{2}K(x+y)^2 - \frac{1}{2}Kx^2$$

$$= \frac{1}{2}K\left[(x+y)^2 - x^2\right]$$

$$= \frac{1}{2}K(x^2 + y^2 + 2xy - x^2)$$

$$= \frac{1}{2}K(y^2 + 2xy)$$

$$= \frac{1}{2}Ky(2x + y)$$

559. A mass of 20 kg moving with a speed of 10 m/s collides with another stationary mass of 5 kg. As a result of the collision, the two masses stick together. The kinetic energy of the composite mass will be

(a) 600 J (b) 800 J
(c) 1000 J (d) 1200 J

CG PET- 2006

Ans. (b) : Given, m_1 = 20 kg , initial velocity (u_1) = 10 m/s, m_2 = 5 kg, u_2 = 0 (rest)

According to law of conservation of momentum

$m_1u_1 + m_2u_2 = (m_1v + m_2v)$

$m_1u_1 + m_2u_2 = (m_1 + m_2)v$

$20 \times 10 + 5 \times 0 = (20 + 5)\ v$

$$v = \frac{200}{25} = 8 \text{ m/s},$$

Kinetic energy of both masses when combine

$$= \frac{1}{2}(m_1 + m_2)v^2$$

$$= \frac{1}{2}(20+5)8^2$$

$$= \frac{1}{2} \times 25 \times 64 = 800\,\text{J}$$

560. Two perfectly elastic particle P and Q of equal mass travelling along the line joining them with velocities 15 m/s and 10 m/s respectively collide. Their velocities after the collision will be (in m/s)

	P Q		P Q
(a)	0 25	(b)	5 20
(c)	10 15	(d)	20 5

CG PET- 2005

Ans. (c) : In perfectly elastic collision of two equal masses with different velocities will interchange after collision.

Velocity of P after collision = 10 m/s

Velocity of Q after collision = 15 m/s

561. A body of mass m moving with velocity v makes a head on collision with another body of mass 2m which is initially at rest. The loss of kinetic energy of the colliding body (mass m) is

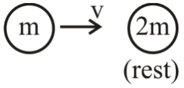
(a) 1/2 of its initial kinetic energy
(b) 1/9 of its initial kinetic energy
(c) 8/9 of its initial kinetic energy
(d) 1/4 of its initial kinetic energy

CG PET- 2004
Punjab PMET-2007

@apna_pdf

Ans. (c) :

Given, $m_1 = m$, $m_2 = 2m$, initial velocity $(u_1) = v$



Final velocity of body 1st in collision

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \frac{2m_2u_2}{m_1 + m_2} \qquad (\because u_2 = 0)$$

$$v_1 = \left(\frac{m - 2m}{m + 2m}\right)u_1 + 0$$

$$v_1 = -\frac{u_1}{3}$$

Loss of kinetic energy,

$$= \frac{1}{2}mu_1^2 - \frac{1}{2}mv_1^2$$

$$= \frac{1}{2}mu_1^2 - \frac{1}{2}m\left(-\frac{u_1}{3}\right)^2$$

$$= \frac{1}{2}mu_1^2 - \frac{1}{2}\frac{mu_1^2}{9}$$

$$= \frac{1}{2}mu_1^2\left[1 - \frac{1}{9}\right]$$

$$= \frac{1}{2} \times \frac{8}{9}mu_1^2 \Rightarrow \frac{8}{9} \times \frac{1}{2}mu_1^2$$

Hence, loss of kinetic energy is $\frac{8}{9}$ of its initial kinetic energy.

562. Two identical masses m moving with velocities u_1 and u_2 collide perfectly in elastically. Find the loss in energy.

(a) $m(u_1 - u_2^2)$
(b) $\frac{m}{4}(u_1 - u_2)^2$
(c) $\frac{m}{2}(u_1 - u_2)^2$
(d) $m(u_1 - u_2)^3$

Manipal UGET-2010

Ans. (b) : Given, mass $= m_1 = m_2 = m$

Velocities $= u_1$ and u_2

Loss in kinetic energy

$$= \frac{1}{2}\frac{m_1m_2}{(m_1 + m_2)}(u_1 - u_2)^2$$

$$= \frac{1}{2}\frac{m.m(u_1 - u_2)^2}{(m + m)} \qquad [\because m_1 = m_2 = m]$$

$$= \frac{m}{4}(u_1 - u_2)^2$$

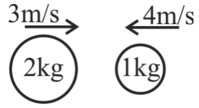
563. A body of mass 2 kg moving with a velocity of 3 m/s collides head on with a body of mass 1kg moving in opposite direction with a velocity of 4 m/s. After collision two bodies stick together and move with a common velocity which in m/s equal to is

(a) 1/4
(b) 1/3
(c) 2/3
(d) 3/4

Manipal UGET-2010

Ans. (c) : Given,

$m_1 = 2$ kg $\qquad m_2 = 1$ kg
$v_1 = 3$ m/s $\qquad v_2 = -4$ m/s



According to law of conservation of momentum

$m_1v_1 + m_2v_2 = (m_1+m_2) \times v$
$2 \times 3 + 1 \times (-4) = (2 + 1) \times v$
$6 - 4 = 3v$

$$v = \frac{2}{3}\text{m/s}$$

After collision, bodies moves with $\frac{2}{3}$m/s of common velocity.

564. A hydrogen atom moving at speed v collides with the another hydrogen atom kept at rest. Find the minimum value of v for which one of the atoms may get ionised. The mass of a hydrogen atom = 1.67×10^{-27} kg. Assume completely inelastic collision.

(a) 7.2×10^4 m/s
(b) 2.3×10^8 m/s
(c) 2.3×10^{10} m/s
(d) 7.2×10^{10} m/s

JCECE-2016

Ans. (a) : Given,

$m_1 = m_2 = m$
and $u_1 = v$, $u_2 = 0$

Let ionized energy $= \Delta E = 13.6$ eV

Let velocity of the inelastic collision $= v_1$

Applying conservation of momentum,

$mu_1 + mu_2 = (m+m)v_1$
$mv + 0 = 2mv_1$

$$v_1 = \frac{v}{2}$$

By energy conservation,

$$\frac{1}{2}mv^2 = \frac{1}{2}(2m)v_1^2 + (\text{ionsied energy}\,\Delta E)$$

$$\frac{1}{2}mv^2 = \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 + \Delta E$$

$$\frac{1}{2}mv^2 - \frac{1}{4}mv^2 = \Delta E$$

$$\frac{1}{4}mv^2 = \Delta E$$

$$v^2 = \frac{4\Delta E}{m}$$

$$v = \sqrt{\frac{4\Delta E}{m}} \qquad \left(\begin{array}{l}\because \Delta E = 13.6 \times 1.6 \times 10^{-19}\,\text{J} \\ m = 1.67 \times 10^{-27}\,\text{kg}\end{array}\right)$$

$$\therefore \quad v_{min} = \sqrt{\frac{4 \times 13.6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}}$$

$$v_{min} = 7.2 \times 10^4\,\text{m/s}$$

@apna_pdf

565. A ball of mass 10 kg is moving with a velocity of 10 m/s. It strikes another ball of mass 5 kg, which is moving in the same direction with a velocity of 4 m/s. If the collision is elastic, then their velocities after collision will be respectively

(a) 12 m/s, 6 m/s (b) 12 m/s, 25 m/s
(c) 6 m/s, 12 m/s (d) 8 m/s, 20 m/s

JCECE-2010

Ans. (c) : Given,

$u_1 = 10$ m/s $\quad m_1 = 10$ kg
$u_2 = 4$ m/s $\quad m_2 = 5$ kg

Let, their velocities after the collision be v_1 and v_2

For elastic collision

Relative velocity of approach = Relative velocity of separation

$$\text{i.e., } e = 1 = \frac{v_2 - v_1}{u_1 - u_2}$$

$$u_1 - u_2 = v_2 - v_1$$
$$10 - 4 = v_2 - v_1$$
$$v_2 - v_1 = 6 \qquad \ldots \text{(i)}$$

By conservation of momentum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$10 \times 10 + 5 \times 4 = 10v_1 + 5v_2$$
$$120 = 10v_1 + 5v_2$$
$$2v_1 + v_2 = 24 \qquad \ldots\text{(ii)}$$

From equation (i) and (ii), we get –

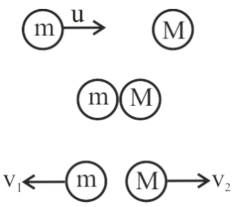
$v_1 = 6$ m/s, $v_2 = 12$ m/s

566. An α-particle of mass m suffers one dimensional elastic collision with a nucleus of unknown mass. After the collision the α-particle is scattered directly backwards losing 75% of its kinetic energy. The mass of the unknown nucleus is:

(a) m (b) 2m
(c) 3m (d) $\frac{3}{2}$m

JCECE-2005

Ans. (c) : Let, m is mass of α-particle and M is mass of the nucleus



From conservation of momentum,

$$mu + 0 = mv_1 + Mv_2$$
$$mu = -mv_1 + Mv_2 \qquad \ldots\text{(i)}$$

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

$$1 = \frac{v_2 - (-v_1)}{u - 0}$$

$$u = v_1 + v_2 \qquad \ldots\text{(ii)}$$

From conservation of energy,

$$\frac{25}{100} \times \frac{1}{2} mu^2 = \frac{1}{2} mv_1^2$$

$$v_1 = 0.5u \qquad \ldots\text{(iii)}$$

from equation (ii) and (iii)

$$u = 0.5u + v_2$$
$$v_2 = 0.5u \qquad \ldots\text{(iv)}$$

from equation (i), (iii) and (iv)

$$mu = -m(0.5u) + M(0.5u)$$
$$mu = -0.5mu + 0.5Mu$$
$$1.5\,mu = 0.5Mu$$
$$M = 3m$$

567. A body of mass 10 kg moving with velocity 10 m/s collides with a stationary body of mass 5 kg. After collision both bodies stick to each other, velocity of the joint body after collision is :

(a) $\frac{3}{10}$ m/s (b) 20 m/s
(c) $\frac{20}{3}$ m/s (d) 15 m/s

JCECE-2003

Ans. (c) : Given:- $m_1 = 10$ kg $\quad m_2 = 5$ kg
$u_1 = 10$ m/s $\quad u_2 = 0$

In an inelastic collision, linear momentum is conserved.

By conservation of linear momentum

$$m_1u_1 + m_2u_2 = (m_1 + m_2)\,v \qquad \ldots\text{(i)}$$

velocity of joint body = v

Substituting the values in equation (i)

$$10 \times 10 + 5 \times 0 = (10 + 5)\,v$$
$$15v = 100$$
$$v = \frac{100}{15} = \frac{20}{3} \text{ m/s}$$

568. Two balls A and B of equal masses moving with speeds of 3 m/s and 5 m/s, collide head-on. If the collision is perfectly elastic, the speeds in m/s of A and B after impact are respectively,

(a) 4 , 4 (b) 3 , 5
(c) 5 , 3 (d) 2 , 8

COMEDK 2011

Ans. (c) : Given:-

$m_A = m_B = m$
$u_A = 3$ m/s
$u_B = 5$ m/s

According to momentum conservation principle

$$m_Au_A + m_B u_B = m_Av_A + m_Bv_B$$
$$3 + 5 = v_A + v_B$$
$$v_A + v_B = 8 \qquad \ldots\text{(i)}$$

Collision is perfectly elastic, so kinetic energy is conserved

$$\frac{1}{2}m_Au_A^2 + \frac{1}{2}m_Bu_B^2 = \frac{1}{2}m_Av_A^2 + \frac{1}{2}m_Bv_B^2$$

$$v_A^2 + v_B^2 = (3)^2 + (5)^2$$

$$v_A^2 + v_B^2 = 34 \qquad \text{(ii)}$$

From equation (i) and (ii), we get –

$v_A = 5$ m/s
$v_B = 3$ m/s

@apna_pdf

569. In an inelastic collision, which of the following is true?

(a) Momentum is conserved but not K.E.
(b) K.E.is conserved, but not momentum.
(c) Both momentum and K.E. are conserved.
(d) Neither momentum nor K.E. are conserved.

COMEDK 2014

Ans. (a) : In an inelastic collision, momentum is conserved but kinetic energy is not conserved. Momentum is conserved in both elastic and inelastic collisions as in both the cases, no external force is applied on them so, no change in momentum.

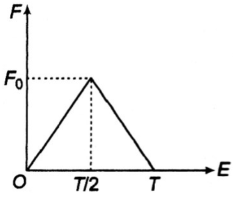
570. A ball strikes against the floor and returns with double the velocity. In which type of collision is it possible?

(a) inelastic
(b) Perfectly inelastic
(c) Perfectly elastic
(d) Not possible

BCECE-2013

Ans. (d) : In this type of collision it is not possible that a ball strikes against the floor and returns with double the velocity because in that case the momentum is not conserved.

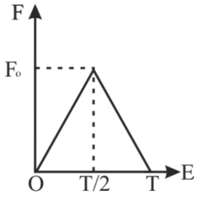
571. A particle of mass m moving with velocity u makes an elastic one dimensional collision with a stationary particle of mass m. They are in contact for a short time T. Their force of interaction increases from zero to F_0 linearly in time T/2 and decreases linearly to zero in further time T/2 (shown in figure). The magnitude of F_0 is–



(a) mu/2T
(b) mu/T
(c) 2mu/T
(d) None of these

BCECE-2012

Ans. (c) :



In elastic one dimensional collision particle rebounds with same speed in opposite direction. Therefore change in linear momentum of any particle will be mu. Now impulse or area under F-T graph gives the change in linear momentum.

$$|\Delta P| = |\text{Impulse}| = F.\Delta T$$
$$= \text{area under } F - T \text{ graph}$$
$$mu = \frac{1}{2} \times T \times F_0$$
$$F_0 = \frac{2mu}{T}$$

572. A ball of mass m moves with speed v and it strikes normally with a wall and reflected back normally. If its time of contact with wall is t, then find force exerted by ball on the wall.

(a) $\frac{2mv}{t}$
(b) $\frac{mv}{t}$
(c) mvt
(d) $\frac{mv}{2t}$

BCECE-2005

Ans. (a) : Initial velocity of ball = v
final velocity = – v
Change in velocity = v – (– v) = 2v
Newton's second law

$$F = ma$$
$$F = \frac{m\,\Delta v}{\Delta t}$$
$$F = \frac{m(2v)}{t}$$
$$F = \frac{2\,mv}{t}$$

573. A bullet of mass 0.1kg is fired with a speed of 100 m/s. The mass of gun being 50 kg. Then, the velocity of recoil become :

(a) 0.05 m/s
(b) 0.5 m/s
(c) 0.1 m/s
(d) 0.2 m/s

BCECE-2004

Ans. (d) : Given,
m = 0.1 kg
v = 100 m/s
Law of conservation of momentum

$$P = mv$$
$$P = 0.1 \times 100 = 10 \text{ kg m/s}$$

Mass of Gun = 50 kg

So,

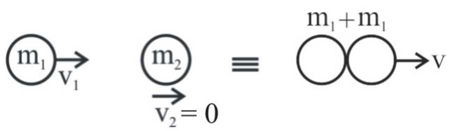
$$\text{Velocity of recoil } = \frac{10 \text{ kg m/s}}{50 \text{ kg}} = \frac{1}{5}$$
$$= 0.2 \text{ m/sec}.$$

574. A body of mass a, moving with a velocity b collides with a body of mass c, at rest and sticks at to it. They move together with a velocity given by:

(a) $\frac{ac}{a+b}$
(b) $\frac{ab}{a+c}$
(c) $\frac{a+b}{ac}$
(d) $\frac{b+c}{ab}$

BCECE-2003

Ans. (b) : In inelastic collision momentum remains conserved. The extreme inelastic collision is one in which the colliding objects stick together after collision.



@apna_pdf

From conservation of momentum

$$m_1v_1 + m_2v_2 = (m_1 + m_2)\,v$$
$$m_1 = a \quad v_1 = b$$
$$m_2 = c \quad v_2 = 0$$
$$a.b + c.0 = (a + c)\,v$$
$$v = \frac{ab}{a+c}$$

575. A body B of mass m moving forward with velocity v along the x-axis, collides elastically with a stationary object C of mass 2m at the origin. After the collision, body B moves backward along the x-axis. Given that the kinetic energy of the system is conserved, what is the speed of the object C after the collision?

(a) $\frac{2v}{3}$ (b) $\frac{v}{2}$

(c) $\frac{v}{3}$ (d) $\frac{3v}{4}$

SCRA-2014, 2009

Ans. (a) : Given that,

Mass of body B = m

Mass of body C = 2m

Let velocity of C after collision be v_c and Let velocity of B after collision be v_b

Since, momentum and kinetic energy of the system is conserved,

Therefore,

$$m.v = -mv_b + 2mv_c$$
$$v = -v_b + 2v_c$$
$$v_b = 2v_c - v \qquad ...(i)$$
$$(K.E)_i = (K.E)_f$$
$$\frac{1}{2}mv^2 = \frac{1}{2}mv_b^2 + \frac{1}{2}\times 2mv_c^2$$
$$v^2 = v_b^2 + 2v_c^2$$
$$v^2 = (2v_c - v)^2 + 2v_c^2$$
$$v^2 = 4v_c^2 + v^2 - 4vv_c + 2v_c^2$$
$$6v_c^2 - 4vv_c = 0$$
$$2v_c(3v_c - 2v) = 0$$
$$\because v_c \neq 0$$
$$3v_c = 2v$$
$$\boxed{v_c = \frac{2}{3}v}$$

576. If two bodies stick together after collision and move as a single body, the collision is said to be

(a) perfectly inelastic (b) elastic

(c) inelastic (d) perfectly elastic

J&K CET- 2011

Ans. (a) : If two bodies stick together after collision and moves as a single body, the collision is said to be perfectly inelastic collision.

$$\text{Coefficient of restitution (e)} = \frac{\text{Final relative velocity}}{\text{Initial relative velocity}}$$

If both the bodies move as a single body after the collision ,

$$v_1 = v_2$$
$$v_1 - v_2 = 0$$
final relative velocity =0

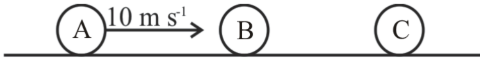
So , e = 0

e = 0, for perfectly inelastic collision

e = 1, for perfectly elastic collision

A perfectly inelastic collision is one in which the maximum amount of kinetic energy has been lost during a collision, making it the most extreme case of an inelastic collision.

577. Three identical spherical balls A, B and C are placed on a table as shown in the figure along a straight line. B and C are at rest initially. The ball A hits B head on with a speed of 10 m s^{-1}. Then after all collisions (assumed to be elastic) A and B are brought to rest and C takes off with a velocity of

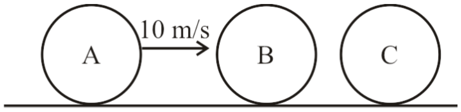


(a) 5 m s^{-1} (b) 10 m s^{-1}

(c) 2.5 m s^{-1} (d) 7.5 m s^{-1}

J&K CET- 2010

Ans. (b) : Since A,B and C are identical balls, if any of the two balls undergo elastic collision, they will exchange their velocities.



When ball A collides with B and comes to rest.

$\Rightarrow$ $P_i = P_f$

$m \times 10 = mv$

$\Rightarrow$ $v = 10$ m/s

Similarly when B collides with C, B comes to rest and C starts moving ahead with a speed of 10 m/s.

578. In inelastic collision,

(a) momentum, kinetic energy and total energy are conserved.

(b) momentum, kinetic energy and total energy are not conserved.

(c) momentum and kinetic energy are conserved but total energy is not conserved.

(d) total energy and momentum are conserved but kinetic energy is not conserved.

J&K CET- 2009

Ans. (d) : In an inelastic collision, total energy and momentum are conserved but kinetic energy is not conserved. There is a loss of kinetic energy.

579. A body of mass m_1 collides elastically with another body of mass m_2 at rest. If the velocity of m_1 after collision becomes $\frac{2}{3}$ times its initial velocity, the ratio of their masses is

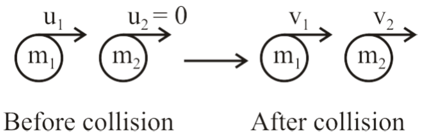
(a) 1 : 5 (b) 5 : 1

(c) 5 : 2 (d) 2 : 5

J&K CET- 2007

@apna_pdf

Ans. (b) :



u_1
$u_2 = 0$
m_1
m_2
v_1
v_2
m_1
m_2
Before collision
After collision

We derive elastic equation as,

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$\because\ u_2 = 0$$

$$\therefore\ v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$

$$\text{Given, } v_1 = \frac{2}{3}u_1$$

So, $$\frac{2}{3}u_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$

$$2\,(m_1+m_2) = 3(m_1-m_2)$$
$$2m_1 + 2m_2 = 3m_1-3m_2$$
$$5m_2 = m_1$$
$$5 = \frac{m_1}{m_2}$$
$$m_1 : m_2 = 5:1$$

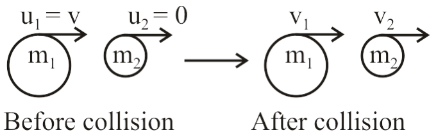
580. In a head on elastic collision of a very heavy body moving at v with a light body at rest, velocity of heavy body after the collision is

(a) v (b) 2v

(c) zero (d) v/2

J&K CET- 2006

Ans. (a) :



$u_1 = v$
$u_2 = 0$
m_1
m_2
v_1
v_2
m_1
m_2
Before collision
After collision

Given,

$m_1 >> m_2$ and $u_2 = 0$

We derive elastic equation as,

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v$$

As $m_1 >>> m_2$, neglecting m_2

$$v_1 = \frac{m_1}{m_1}v$$

$$v_1 = v$$

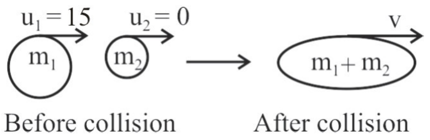
581. A 2.5 kg mass moving at a speed of 15 m/sec collides with 5 kg object initially at rest. They stick together. Find the velocity of the combination after the collision.

(a) 15 m/s (b) 5 m/s

(c) 20 m/s (d) None of these

J&K CET- 2002

Ans. (b) :



$u_1 = 15$
$u_2 = 0$
m_1
m_2
v
$m_1 + m_2$
Before collision
After collision

Given that,

$m_1 = 2.5$ kg, $u_1 = 15$m/sec

$m_2 = 5$ kg, $u_2 =$ m/sec

Applying conservation of momentum,

$$P_i = P_f$$
$$m_1u_1+m_2u_2 = (m_1+m_2)v$$
$$(2.5 \times 15) + (5\times0) = (2.5+5)v$$
$$(2.5 \times 15) = 7.5v$$
$$v = \frac{2.5\times15}{7.5}$$
$$\boxed{v = 5\ m/s}$$

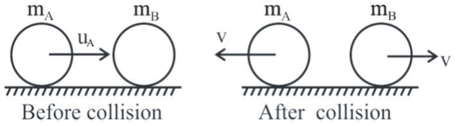
582. Particle A makes a perfectly elastic collision with another particle B at rest. They fly apart in opposite directions with equal speeds. The ratio of their masses m_A/m_B is

(a) 1/2 (b) 1/3

(c) 1/4 (d) $1/\sqrt{3}$

J&K CET- 1999

Ans. (b) :



m_A
m_B
u_A
m_A
m_B
v
v
Before collision
After collision

Since, there is no external force, hence

Given that,

$$v_A = -v$$
$$v_B = v$$
$$u_B = 0\ m/s$$

From conservation of linear momentum

$$m_A\,u_A + m_Bu_B + m_Av_A + m_Bv_B$$
$$m_Au_A + m_B \times 0 = m_A\,(-v) + m_B\,(v)$$
$$m_Au_A = (-m_A+m_B)v \qquad ....(i)$$

As we know, collision is elastic.

$$v_B - v_A = e(u_A - u_B)$$

$$\Rightarrow\ e = 1 \Rightarrow \frac{v-(-v)}{u_A - 0} = 1$$

$$\text{Or}\quad 2v = u_A \qquad ....(ii)$$

From eq^n. (i) and (ii),

$$m_A(2v) = (-m_A+m_B)\,v$$
$$2m_A = -m_A + m_B$$
$$3m_A = m_B$$

or $$\frac{m_A}{m_B} = \frac{1}{3}$$

583. An object of mass m and velocity v collides head-on with another body of mass 2m which is lying at rest. The ratio of kinetic energy of colliding body before and after collision will be

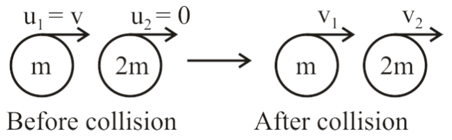
(a) 4 : 1 (b) 2 : 1

(c) 3 : 1 (d) 9 : 1

J&K CET- 1998

@apna_pdf

Ans. (d) :



For body of mass (m)

$$(\text{K.E.})_i = \frac{1}{2}mv^2 \qquad [\text{Before collision}]$$

$$(\text{K.E.})_f = \frac{1}{2}mv_1^2 \qquad [\text{After collision}]$$

Assume as elastic collision:

Now, as we derived elastic equation-

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v$$

$$v_1 = \frac{m - 2m}{3m}v$$

$$v_1 = -\frac{1}{3}v$$

$$(\text{K.E.})_f = \frac{1}{2}m\left(-\frac{1}{3}v\right)^2$$

$$(\text{K.E.})_f = \frac{1}{2}mv^2\left(\frac{1}{9}\right)$$

So, $$\frac{(\text{K.E.})_i}{(\text{K.E.})_f} = \frac{\frac{1}{2}mv^2}{\frac{1}{2}mv^2\left(\frac{1}{9}\right)}$$

$$\frac{(\text{K.E.})_i}{(\text{K.E.})_f} = \frac{9}{1}$$

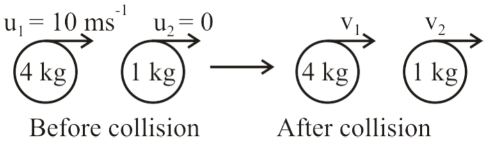
$$(\text{K.E})_i : (\text{K.E})_f = 9:1$$

584. A 4 kg ball makes an elastic head on collision with a 1 kg ball. Before the collision the speed of the 4 kg ball is 10 m s^{-1} and the speed of the 1 kg ball is zero. The speed of the 1 kg ball after collision is

(a) zero
(b) less than 10 m s^{-1}
(c) equal to 10 m s^{-1}
(d) greater than 10 m s^{-1}

J&K CET- 1997

Ans. (d) :



Given that,

$u_1 = 10$ m/s , $u_2 = 0$ m/s

$m_1 = 4$ kg, $m_2 = 1$ kg

The formula of velocity is

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)}{(m_2 + m_1)}u_2$$

$$v_2 = \frac{2 \times 4 \times 10}{(4+1)} + \frac{(1-4)}{(1+4)} \times 0$$

$v_2 = 16$ m/s

This is greater than 10 m/s

585. A rubber ball is bounced on the floor of a room which has its ceiling at a height of 3.2 m from the floor. The ball hits the floor with a speed of 10 m/s, and rebounds vertically up. If all collisions simply reverse the velocity of the ball, without changing its speed, then how long does it take the ball for a round trip, from the moment it bounces from the floor to the moment it returns back to it? Acceleration due to gravity is 10 m/s^2

(a) 4 s
(b) 2 s
(c) 0.8 s
(d) 1.2 s

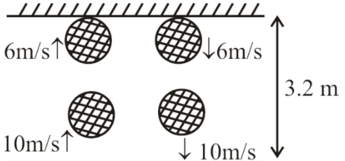
J&K-CET-2012

Ans. (c) : Given,

Height of ceiling = 3.2 m

Speed of ball = 10 m/s

To find - Time taken for round trip



Applying laws of motion,

$$v_c^2 = u_f^2 + 2as$$

$$v_c^2 = 10^2 - 2 \times 10 \times 3.2$$

$v_c = 6$ m/s

Now, to find total time (t) = $t_1 + t_2$

t_1 = time taken to reach ceiling from floor

t_2 = time taken to reach floor from ceiling

Applying laws of motion,

1st condition	2nd condition
$v_c = v_f + at_1$	$v_f = v_c + at_2$
$6 = 10 - 10 \times t_1$	$10 = 6 + 10 \times t_2$
$t_1 = 4/10 = 0.4$ sec	$t_2 = 0.4$ sec

$\therefore$ Total time (t) = $t_1 + t_2$

t = 0.8 sec

586. Which of the following is true for any collision?

(a) Both linear momentum and kinetic energy are conserved
(b) Neither linear momentum nor kinetic energy may be conserved
(c) Linear momentum is always conserved however, kinetic energy may or may not be conserved
(d) Kinetic energy is always conserved, but linear momentum may or may not be conserved

J&K-CET-2012

@apna_pdf

Ans. (c) : Basic law of physics that linear momentum is always conserved there is no known exception. Kinetic energy does not need to conserve because it can turn into other forms of energy. The sum of all types of energy (including kinetic energy) is the same before and after collision.

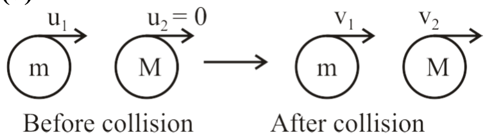
587. A neutron in a nuclear reactor collides head on elastically with the nucleus of a carbon atom initially at rest. The fraction of kinetic energy transferred from the neutron to the carbon atom is

(a) $\frac{11}{12}$ (b) $\frac{2}{11}$

(c) $\frac{48}{121}$ (d) $\frac{48}{169}$

J&K-CET-2016

Ans. (d) :



m = mass of Neutron

M = mass of carbon atom

M = 12 m

$$K_i = \frac{1}{2}mu^2, \quad K_f = \frac{1}{2}mv_1^2 \quad \left(\begin{array}{c} v_1 = \text{velocity after collision} \\ \text{of Neutron} \end{array}\right)$$

$$v_1 = \frac{(m-M)u}{m+M}$$

So, $$K_f = \frac{1}{2}m\left(\frac{m-M}{m+M}\right)^2 u^2$$

$$\frac{K_f}{K_i} = \left(\frac{m-M}{m+M}\right)^2$$

$$\frac{K_f}{K_i} = \left(\frac{m-12m}{m+12m}\right)^2 = \left(\frac{-11}{13}\right)^2 = \frac{121}{169}$$

Required fraction of K.E, $f = 1 - \frac{K_f}{K_i}$

$$f = 1 - \frac{121}{169}$$

$$f = \frac{169-121}{169}$$

$$f = \frac{48}{169}$$

588. Four identical balls, A, B, C and D are placed on a smooth horizontal plane such that B, C and D are in one line and are in contact and A is kept along the same line but a distance away. Now, A is set in motion with speed v along the line and it strikes the ball B. After this collision, which is elastic.

(a) Balls A, B, C will be at rest and D will move with speed v

(b) A will be at rest, where B, C and D will move together with speed v/3

(c) A will rebound with speed v/2 while B, C and D will move together with speed v/2

(d) A, B, C and D will move together with speed v/4

Manipal UGET-2016

Ans. (a) : Given case is a elastic collision, therefore the entire energy of A is transferred to D through ball B and C.

So, balls A, B and C will be at rest and D will move with speed v.

589. A moving body with a mass m_1 strikes a stationary body of mass m_2. The masses m_1 and m_2 should be in the ratio m_1/m_2 so as to decrease the velocity of the first body 1.5 times assuming a perfectly elastic impact. Then, the ratio m_1/m_2 is.

(a) 5

(b) 1/5

(c) 1/25

(d) 25

UP CPMT-2014

Ans. (a) : Here, initially m_2 is at rest, $u_2 = 0$ and m_1 is having initial velocity u_1

So, final velocity of m_1 and m_2 is $\frac{2u_1}{3}$ and v_2 respectively.

Now, linear momentum between two masses m_1 and m_2 exerts net external force is zero.

$$P_i = P_f$$

$$m_1u_1 + m_2u_2 = m_1\left(\frac{2u_1}{3}\right) + m_2v_2 \quad ....(i)$$

Now, along line of impact, applying law of restitution

$$e = \frac{V_{separation}}{V_{approach}} = 1 \quad [\because \text{perfectly elastic collision}]$$

$$1 = \frac{v_2 - \frac{2u_1}{3}}{u_1} \Rightarrow v_2 = \frac{5u_1}{3}$$

Putting above value in equation (i), we get –

$$m_1u_1 = m_1\left(\frac{2u_1}{3}\right) + m_2\left(\frac{5u_1}{3}\right)$$

$$\frac{m_1}{m_2} = 5$$

590. A body of mass 3 kg moving with a velocity $\left(2\hat{i} + 3\hat{j} + 3\hat{k}\right)$m/s collides with another body of mass 4 kg moving with a velocity $\left(3\hat{i} + 2\hat{j} - 3\hat{k}\right)$m/s. The two bodies stick together after collision. The velocity of the composite body is

(a) $\frac{1}{7}\left(4\hat{i} + 6\hat{j} - 3\hat{k}\right)$ (b) $\frac{1}{7}\left(18\hat{i} + 17\hat{j} - 3\hat{k}\right)$

(c) $\frac{1}{7}\left(6\hat{i} + 4\hat{j} - 6\hat{k}\right)$ (d) $\frac{1}{7}\left(9\hat{i} + 8\hat{j} - 6\hat{k}\right)$

TS EAMCET (Engg.)-2016

@apna_pdf

Ans. (b) : Given, $m_1 = 3$ kg

$$v_1 = \left(2\hat{i} + 3\hat{j} + 3\hat{k}\right) m/s$$

$m_2 = 4$ kg

$$v_2 = \left(3\hat{i} + 2\hat{j} - 3\hat{k}\right) m/s$$

Applying the law of conservation of momentum,

$$m_1v_1 + m_2v_2 = (m_1 + m_2)v$$

$$3(2\hat{i} + 3\hat{j} + 3\hat{k}) + 4\left(3\hat{i} + 2\hat{j} - 3\hat{k}\right) = (3+4)v$$

$$6\hat{i} + 9\hat{j} + 9\hat{k} + 12\hat{i} + 8\hat{j} - 12\hat{k} = 7v$$

$$18\hat{i} + 17\hat{j} - 3\hat{k} = 7v$$

$$v = \frac{1}{7}\left(18\hat{i} + 17\hat{j} - 3\hat{k}\right)$$

591. A particle of mass 'm' is moving horizontally with a speed 'v' towards a rigid wall which is moving in the opposite direction with a constant velocity u. Assuming elastic impact between the wall and the particle, the work done by the wall in reflecting the particle is:

(a) $\frac{1}{2}m(v+u)^2$ (b) $\frac{1}{2}m(v+u)$

(c) 2 muv (d) 2 mu(u + v)

SRM JEE - 2007

Ans. (d) : Since, the collision between the particle and the wall is elastic,

∴ Velocity of separation = Velocity of approach

$$v' - u = v + u$$

$$v' = v + 2u \quad \text{.... (i)}$$

[v' = velocity of particle after collision]

Work done (W) by the wall in reflecting the particle will be given by change in the K.E. of the particle.

$$-W = \frac{1}{2}mv^2 - \frac{1}{2}mv'^2$$

Putting the value of v' from equation (i), we get

$$-W = \frac{1}{2}mv^2 - \frac{1}{2}m(v+2u)^2$$

$$-W = \frac{1}{2}mv^2 - \frac{1}{2}m(v^2 + 4u^2 + 4uv)$$

$$-W = \frac{1}{2}m(-4u^2 - 4uv)$$

$$-W = \frac{-4}{2}mu(u+v)$$

$$-W = -2mu(u+v)$$

$$\therefore \quad W = 2mu(u+v)$$

592. Two equal spheres A and B lie on a smooth horizontal circular groove at opposite ends of a diameter. Sphere A is projected along the groove and at the end of time T impinges on sphere B. If e is the coefficient of restitution, the second impact will occur after a time.

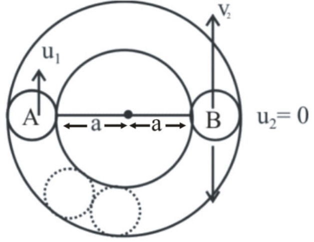
(a) T (b) eT

(c) $\frac{2T}{e}$ (d) 2eT

Assam CEE-2014

Ans. (c) : Let, u_1 = Initial velocity of A

u_2 = Initial velocity of B



$$T = \frac{\pi a}{u_1}$$

$$u_1 = \frac{\pi a}{T} \quad \text{.... (i)}$$

$$T_2 = \frac{2\pi a}{v_2 - v_1} \quad \text{....(ii)}$$

$$e = \frac{\text{velocity of separation}}{\text{velocity of approach}}$$

$$e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{v_2 - v_1}{u_1}$$

Where, v_1 and v_2 are the velocities of A and B after the collision.

$$v_2 - v_1 = eu_1$$

From (ii), we get

$$T_2 = \frac{2\pi a}{eu_1}$$

Putting the value of u_1 from equation (i), we get

$$T_2 = \frac{2\pi a}{e \times \frac{\pi a}{T}}$$

$$T_2 = \frac{2T}{e}$$

593. A sphere of mass m moving with velocity v hits in elastically with another stationary sphere of same mass. The ratio of their final velocities will be (in terms of e)

(a) $\frac{v_1}{v_2} = \frac{1+e}{1-e}$ (b) $\frac{v_1}{v_2} = \frac{1-e}{1+e}$

(c) $\frac{v_1}{v_2} = \frac{1+e}{2}$ (d) $\frac{v_1}{v_2} = \frac{1-e}{2}$

JIPMER-2016

Ans. (b) : Let initial velocity $(u_1) = u$, $u_2 = 0$

After collision, velocity get v_1 and v_2.

$$m_1 = m_2 = m$$

By the law of conservation of momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$mu + 0 = mv_1 + mv_2$$

$$v_1 + v_2 = u \quad \text{..... (i)}$$

By the Newton's experimental law,

$$v_2 - v_1 = e(u_1 - u_2) = e(u - 0)$$

$$v_2 - v_1 = eu \quad \text{...... (ii)}$$

@apna_pdf

From equation (i), we get

$$v_2 - v_1 = e(v_1 + v_2)$$

$$v_2 - ev_2 = (v_1 + ev_1)$$

$$v_2(1-e) = v_1(1+e)$$

$$v_1 : v_2 = (1-e):(1+e) \text{ or } \frac{v_1}{v_2} = \left(\frac{1-e}{1+e}\right)$$

594. A body of mass 5 kg makes an elastic collision with another body at rest and continues to move in the original direction after collision with a velocity equal to $\frac{1}{10}$ th of its original velocity. Then the mass of the second body is

(a) 4.09 kg (b) 0.5 kg
(c) 5 kg (d) 5.09 kg

AP EAMCET -2009
BITSAT-2009

Ans. (a) : Given, $m_1 = 5$ kg, $u_1 = u$, $u_2 = 0$, $v_1 = \frac{u}{10}$

Let, mass of second body (m_2) = M

According to law of conservation of momentum–

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$5 \times u + M \times 0 = 5 \times \frac{u}{10} + M \times v_2$$

$$5u - \frac{u}{2} = M \times v_2$$

$$\frac{9u}{2} = M \times v_2 \quad .... (i)$$

Now, $(v_2 - v_1) = -e(u_2 - u_1)$

For elastic collision, e = 1

$$v_2 - \frac{u}{10} = -1(0-u)$$

$$v_2 = u + \frac{u}{10}$$

$$v_2 = \frac{11u}{10}$$

Putting the value of v_2 in equation (i), we get –

$$\frac{9u}{2} = M \times \frac{11u}{10}$$

$$M = \frac{45}{11}$$

$$M = 4.09 \text{ kg}$$

595. A ball P moving with a speed of v ms^{-1} collides directly with another identical ball Q moving with a speed 10 ms^{-1} in the opposite direction. P comes to rest after the collision. If the coefficient of restitution is 0.6, the value of v is

(a) 30 ms^{-1} (b) 40 ms^{-1}
(c) 50 ms^{-1} (d) 60 ms^{-1}

AP EAMCET -2015

Ans. (b) : Given, u_1 = v m/s, u_2 = 10 m/s, v_1 = 0, e = 0.6

Let, mass of ball P and Q is = m

Let, v_2 is velocity of ball Q after collision

According to law of conservation of momentum –

$$\because \quad m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$mv + m(-10) = m \times 0 + m \times v_2$$

$$(v-10) = v_2$$

We know that the coefficient of restitution

$$e = \frac{(v_2 - v_1)}{(u_2 + u_1)} \quad \text{(Opposite direction)}$$

$$0.6 = \frac{(v-10-0)}{(10+v)}$$

$$6 + 0.6\,v = v - 10$$

$$0.4\,v = 16$$

$$v = 40 \text{ ms}^{-1}$$

596. A 1 kg ball moving with a speed of 6 ms^{-1} collides head -on with a 0.5 kg ball moving in the opposite direction with a speed of 9 ms^{-1}. If the coefficient of restitution is $\frac{1}{3}$, then the energy lost in the collision is

(a) 303.4 J (b) 66.7 J
(c) 33.3 J (d) 67.8 J

AP EAMCET -2016

Ans. (c) : Given, mass of first ball (m_1) = 1kg, speed of first ball (u_1) = 6 m/s, mass of second ball (m_2) = 0.5 kg, speed of second ball (u_2) = 9 m/s, coefficient of restitution (e) = $\frac{1}{3}$

We know that-

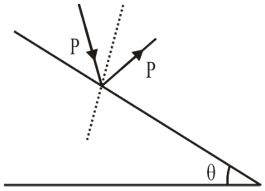
$$\Delta K.E. = \frac{m_1.m_2}{2(m_1+m_2)}(1-e^2)(u_1+u_2)^2$$

Putting the value of these, we get –

$$= \frac{1 \times 0.5}{2(1+0.5)}\left[1 - \left(\frac{1}{3}\right)^2\right](6+9)^2$$

$$\Delta K.E. = \frac{1}{2} \times \frac{1}{3} \times \frac{8}{9} \times (15)^2 = \frac{1}{6} \times \frac{8}{9} \times 225 = 33.33 \text{ J}$$

597. A particle P falling vertically from a height hits a plane inclined to the horizontal at an angle θ with speed v and rebounds elastically, as shown. The distance along the plane where it hits the second time is



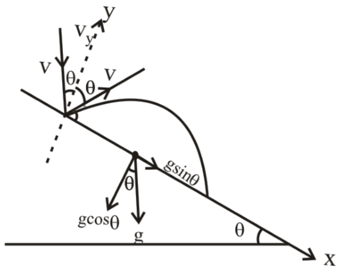
(a) $\frac{4v^2 \sin^2\theta}{g}$ (b) $\frac{v^2 \sin\theta}{2g}$

(c) $\frac{4v^2 \sin\theta}{g}$ (d) $\frac{v^2 \sin\theta}{4g}$

AMU-2014

@apna_pdf

Ans. (c) :



Collision is elastic so speed after the collision is v.

$v_x = v\cos(90^o - \theta) = v\sin\theta$

$v_y = v\sin(90^o - \theta) = v\cos\theta$

$a_x = g\sin\theta,\ a_y = g\cos\theta$

Suppose after time t ball hits the inclined plane second time.

Motion along y-axis

$$y = v_y t + \frac{1}{2}a_y t^2 \quad \text{[Using kinematic equation]}$$

$$0 = v\cos\theta t + \frac{1}{2}(-g\cos\theta)t^2$$

$$t = \frac{2v}{g}$$

Motion along x-axis. Let the distance be x.

$$\therefore \quad x = v_x t + \frac{1}{2}a_x t^2$$

$$x = v\sin\theta\left(\frac{2v}{g}\right) + \frac{1}{2}(g\sin\theta)\frac{4v^2}{g^2}$$

$$x = \frac{2v^2\sin\theta}{g} + \frac{2v^2\sin\theta}{g}$$

$$x = \frac{4v^2\sin\theta}{g}$$

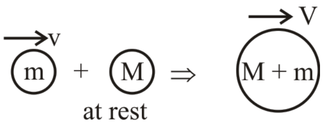
598. An object of mass m moving with a speed v makes a completely inelastic collision with another object of mass M, initially at rest. The kinetic energy of the composite object, of mass (m +M), may be equated to

(a) $\frac{1}{2}(m+M)v^2$ (b) $\frac{1}{2}mv^2$

(c) $\frac{1}{2}\frac{m^2v^2}{(m+M)}$ (d) $\frac{1}{2}\frac{(m+M)v^2}{m}$

AMU-2006

Ans. (c) :



According to law of conservation of momentum

$m_1v_1 + m_2v_2 = (m_1 + m_2)\ v$

By putting the value of given data,

$mv + M \times 0 = (m + M)V \qquad \{\because v_2 = 0\}$

$$V = \frac{mv}{(m+M)} \qquad \text{....(i)}$$

Now, kinetic energy of composite object,

$$K.E. = \frac{1}{2}(m+M)V^2$$

From equation (i),

$$K.E. = \frac{1}{2}\times(m+M)\times\left(\frac{mv}{m+M}\right)^2$$

$$K.E. = \frac{1}{2}\frac{m^2v^2}{(m+M)}$$

599. A body of mass 1.0 kg strikes elastically with another body at rest and continues to move in the same direction with one-fourth of its initial velocity. The mass of the other body is

(a) 0.6 kg (b) 2.4 kg

(c) 3.0 kg (d) 4.0 kg

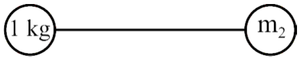
AMU-2011

Ans. (a) : Given that,

$m_1 = 1$ kg $\quad m_2 = ?$

$u_1 = u \qquad v_1 = u/4$

$u_2 = 0 \qquad v_2 = ?$



According to law of conservation of momentum –

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$$1 \times u + m_2 \times 0 = 1 \times \frac{u}{4} + m_2 \times v_2$$

$$u = \frac{u}{4} + m_2v_2$$

$$m_2v_2 = u - \frac{u}{4} = \frac{3u}{4}$$

$$m_2v_2 = \frac{3u}{4} \qquad \text{... (i)}$$

For elastic collision –

$v_1 - v_2 = -e(u_1 - u_2)$

$$\frac{u}{4} - v_2 = -1(u_1 - 0) \qquad (\because e = 1)$$

$$\frac{u}{4} - v_2 = -u \qquad (\because u_1 = u)$$

$$v_2 = \frac{u}{4} + u = \frac{5v}{4}$$

$$v_2 = \frac{5u}{4}$$

Putting the value of v_2 in equation (i) we have,

$$m_2 \times \frac{5u}{4} = \frac{3u}{4}$$

$$m_2 = \frac{3\times4}{5\times4} = 0.6 \text{ kg}$$

600. A ball dropped from a height of 2 m rebounds to a height of 1.5 m after hitting the ground. Then the percentage of energy lost is

(a) 25 (b) 30

(c) 50 (d) 100

(e) 200

Kerala CEE - 2011

@apna_pdf

Ans. (a) : Let, mass of the ball is m

Potential energy at height (H) = mgH

Potential energy at height (h) = mgh

Loss in Potential energy (ΔP.E.) = mg (H – h)

$$\text{Percentage loss in the P.E.} = \frac{mg(H-h)}{mgH}\times 100\%$$

$$= \frac{mg(2-1.5)}{mg\times 2}\times 100\%$$

$$= \frac{0.5}{2}\times 100\%$$

$$= 25\%$$

601. Two equal masses m_1 and m_2 moving along the same straight line with velocities +3 m/s and – 5 m/s respectively collide elastically. Their velocities after the collision will be respectively

(a) +4m/s for both

(b) −3 m/s and +5 m/s

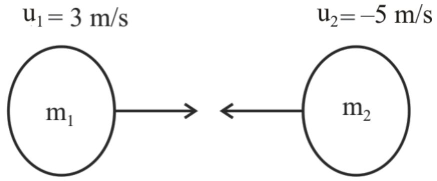
(c) −4 m/s and +4 m/s

(d) −5 m/s and +3 m/s

AIPMT- 1998

Ans. (d) : Let us assume that u_1 and u_2 are the velocities before collision. v_1 and v_2 are velocities after collision.

Given, u_1 = 3 m/s, u_2 = – 5m/s, $m_1 = m_2$ = m



According to conservation of momentum –

$$v_1 = \left(\frac{m_1-m_2}{m_1+m_2}\right)u_1 + \left(\frac{2m_2}{m_1+m_2}\right)u_2$$

$$v_1 = 0 + \frac{2m_1}{2m_1}\times u_2 \qquad (\because m_1 = m_2 = m)$$

$$v_1 = u_2 \qquad (\because u_2 = -5\,m/s)$$

$$\therefore \quad v_1 = -5\,m/s$$

$$v_2 = \left(\frac{2m_1}{m_1+m_2}\right)u_1 + \left(\frac{m_2-m_1}{m_2+m_1}\right)\times u_2$$

$$v_2 = \frac{2m_1}{2m_1}\times u_1 + 0 \qquad (\because m_1 = m_2 = m)$$

$$v_2 = u_1 \qquad (\because u_1 = 3\,m/s)$$

$$\therefore \quad v_2 = 3\,m/s$$

602. A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after the collision, the two balls move together, the loss in kinetic energy due to collision is

(a) 140 J (b) 100 j

(c) 60 J (d) 40 J

AIPMT- 1997

Ans. (c) : Given,

Mass of metal ball, m_1 = 2kg

Velocity of metal ball, $v_1 = 36\text{ km/h} = 36\times\frac{5}{18} = 10\,m/s$

Mass of stationary ball, (m_2) = 3 kg

Velocity of stationary ball, v_2 = 0

According to law of conservation of momentum

$$m_1v_1 + m_2v_2 = (m_1 + m_2)v \quad [v_2 = 0]$$

$$2\times10 + 3\times0 = (2+3)v$$

$$20 = 5v$$

$$v = 4\text{ m/s}$$

Initial kinetic energy,

$$(K.E)_i = \frac{1}{2}mv_1^2$$

$$= \frac{1}{2}\times 2\times(10)^2 = 100\,J$$

Final kinetic energy,

$$(K.E)_f = \frac{1}{2}\times 5\times(4)^2$$

$$(K.E)_f = 40\text{ J}$$

The loss in kinetic energy due to collision,

$$\Delta K.E = (K.E)_i - (K.E)_f$$

$$= (100 - 40)$$

$$\Delta K.E. = 60\,J$$

603. A body of mass m moving with velocity 3 km/h collides with a body of mass 2m at rest. Now, the coalesced mass starts to move with a velocity

(a) 1 km/h (b) 2 km/h

(c) 3 km/h (d) 4 km/h

AIPMT- 1996

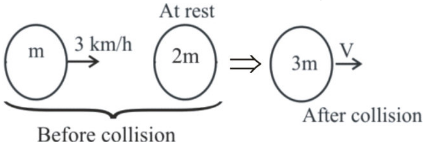
Ans. (a) : Given,

Mass of body (m_1) = m, velocity of first body (v_1) = 3 km/h

Mass of second body (m_2) = 2m

Velocity of second body (v_2) = 0

After collision, mass of the body (M) = m + 2m = 3m



By the law of conservation of momentum, we get

$$mv = m_1v_1 + m_2v_2$$

$$3mv = m\times 3 + 2m\times 0$$

$$v = 1\text{ km/h}$$

604. Two identical balls A and B moving with velocities +0.5 m/s and −0.3 m/s respectively, collide head on elastically. The velocity of the balls A and B after collision will be respectively

(a) +0.5 m/s and +0.3 m/s

(b) −0.3 m/s and +0.5 m/s

(c) +0.3 m/s and 0.5 m/s

(d) −0.5 m/s and +0.3 m/s

AIPMT- 1991
NEET-2016

@apna_pdf

Ans. (b) : Given,

Mass of ball A = mass of ball B

$u_A = 0.5$ m/s $u_B = -0.3$ m/s

After collision,

Let us assume velocity of ball A = v_A and velocity of ball B = v_B

From conservation of momentum,

$$mu_A + mu_B = mv_A + mv_B$$

$$m(u_A + u_B) = m(v_A + v_B)$$

$$u_A + u_B = v_A + v_B$$

$$v_A + v_B = 0.5 - 0.3$$

$$v_A + v_B = 0.2\,m/s \quad ....(i)$$

From energy conservation,

$$\frac{1}{2}mu_A^2 + \frac{1}{2}mu_B^2 = \frac{1}{2}mv_A^2 + \frac{1}{2}mv_B^2$$

$$\frac{1}{2}m\left(u_A^2 + u_B^2\right) = \frac{1}{2}m\left(v_A^2 + v_B^2\right)$$

$$v_A^2 + v_B^2 = u_A^2 + u_B^2$$

$$v_A^2 + v_B^2 = (0.5)^2 + (0.3)^2$$

$$v_A^2 + v_B^2 = 0.34 \quad ....(ii)$$

By solving equation (i) and (ii), we get,

$$v_A = -0.3\,m/s$$

$$v_B = +0.5\text{ m/s}$$

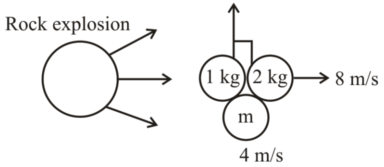
605. An explosion blows a rock into three parts. Two parts go off at right angles to each other. These two are, 1 kg first part moving with a velocity of $12ms^{-1}$ and 2 kg second part moving with a velocity of $8ms^{-1}$. If the third part flies off with a velocity of $4ms^{-1}$, its mass would be

(a) 5 kg (b) 7 kg

(c) 17 kg (d) 3 kg

AIPMT- 2009

Ans. (a) : Apply law of conservation of linear momentum



Momentum of first part = 1×12 = 12 kg m/s

Momentum of second part = 2×8 = 16 kg m/s

$$\therefore \text{ Resultant momentum} = \sqrt{(12)^2 + (16)^2}$$

$$= 20\,kg\,m/s$$

The third part should also have same momentum. Let the mass of the third part be m then,

$$4 \times m = 20$$

$$m = 5kg$$

606. A ball moving with velocity 2 ms^{-1} collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in ms^{-1}) after collision will be

(a) 0, 1 (b) 1, 1

(c) 1, 0.5 (d) 0, 2

AIPMT- 2010

Ans. (a) : Given,

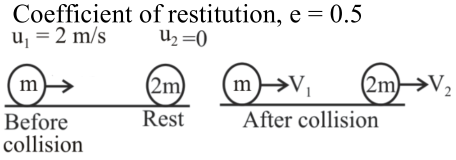
Mass of first ball (m_1) = m

Mass of second ball (m_2) = 2m

Velocity of first ball before collision (u_1) = 2 m/s

Velocity of second ball before collision (u_2) = 0

Coefficient of restitution, e = 0.5



From conservation of momentum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m \times 2 + 2m \times 0 = mv_1 + 2mv_2$$

$$2m = mv_1 + 2mv_2$$

$$2m = m(v_1 + 2v_2)$$

$$v_1 + 2v_2 = 2 \quad ....(i)$$

We know that,

$$e = \frac{\text{velocity of sepration}}{\text{velocity of approach}}$$

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

$$0.5 = \frac{v_2 - v_1}{2 - 0}$$

$$v_2 - v_1 = 1 \quad ....(ii)$$

On Adding the equation (i) and (ii), we get

$$3v_2 = 3$$

$$\therefore \quad v_2 = 1\,m/s$$

Putting the value of v_2 in equation (ii) we get,

$$1 - v_1 = 1$$

$$v_1 = 1 - 1$$

$$\therefore \quad v_1 = 0\,m/s$$

607. On a frictionless surface, a block of mass m moving at speed v collides elastically with another block of same mass m which is initially at rest. After collision the first block moves at an angle θ to its initial direction and has a speed v/3. The second block's speed after the collision is

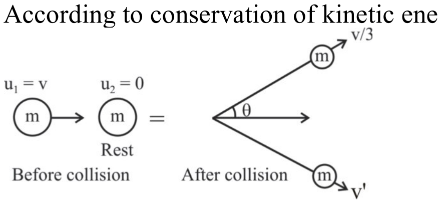
(a) $\frac{2\sqrt{2}}{3}v$ (b) $\frac{3}{4}v$

(c) $\frac{3}{\sqrt{2}}v$ (d) $\frac{\sqrt{3}}{2}v$

AIPMT- 2015

Ans. (a) : The situation is shown in the figure.

According to conservation of kinetic energy



$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}m\left(\frac{v}{3}\right)^2 + \frac{1}{2}mv'^2$$

$$\frac{1}{2}mv^2 = \frac{1}{2}m \times \frac{v^2}{9} + \frac{1}{2}mv'^2$$

@apna_pdf

$$\frac{1}{2}mv^2 = \frac{1}{2}m\left[\frac{v^2}{9} + v'^2\right]$$

$$v^2 = \frac{v^2}{9} + v'^2$$

$$v'^2 = v^2 - \frac{v^2}{9}$$

$$v'^2 = \frac{8v^2}{9}$$

$$v' = \sqrt{\frac{8v^2}{9}} = \frac{\sqrt{8}v}{3} = \frac{2\sqrt{2}}{3}v$$

608. A rubber ball is dropped from a height of 5m on a planet where the acceleration due to gravity is not known. On bouncing it rises to 1.8 m. The ball loses its velocity on bouncing by a factor of

(a) 16/25 (b) 2/5
(c) 3/5 (d) 9/25

AIPMT- 1998

Ans. (b) : Given, $h_1 = 5m$, $h_2 = 1.8m$
According to question-
When ball dropped from a height h on reaching the surface velocity is-

$$v_1 = \sqrt{2gh_1}$$

$$v_1 = \sqrt{10g}$$

Let v_2 be the velocity with which the ball bound is will attain a height h_2 given by

$$v_2 = \sqrt{2gh_2}$$

$$v_2 = \sqrt{3.6g}$$

Hence, loss in velocity(v)-

$$v = \frac{v_1 - v_2}{v_1}$$

$$= \frac{\sqrt{10g} - \sqrt{3.6g}}{\sqrt{10g}} = 1 - \frac{\sqrt{3.6g}}{\sqrt{10g}} = 1 - \frac{3}{5}$$

$$v = \frac{2}{5}$$

609. A ball is thrown vertically downwards from a height of 20m with an initial velocity v_0. It collides with the ground, loses 50%of its energy in collision and rebounds to the same height. The initial velocity v_0 is (Take, $g = 10\ ms^{-2}$)

(a) $14\ ms^{-1}$ (b) $20\ ms^{-1}$
(c) $28\ ms^{-1}$ (d) $10\ ms^{-1}$

AIPMT- 2015

Ans. (b) : Given that,
$g = 10\ m/s^2$
$h = 20\ m$
Initial velocity = v_0
Suppose the ball rebounds with speed v,

$$\therefore \quad v = \sqrt{2gh}$$

$$v = \sqrt{2 \times 10 \times 20}$$

$v = 20\ m/s$

Energy of a ball just after rebound,

$$E = \frac{1}{2}mv^2$$

$$E = \frac{1}{2} \times m \times (20)^2$$

$E = 200\ m$

As, 50% of energy loses in collision means just before collision energy is 400m.
According to law of conservation of energy, we have

$$\frac{1}{2}mv_0^2 + mgh = 400m$$

$$\frac{1}{2}mv_0^2 + m \times 10 \times 20 = 400m$$

$$v_0 = 20\ m/s$$

610. Two particles of masses m_1 and m_2 move with initial velocities u_1 and u_2. On collision, one of the particles get excited to higher level, after absorbing energy ε. If final velocities of particles be v_1 and v_2, then we must have

(a) $m_1^2 u_1 + m_2^2 u_2 - \varepsilon = m_1^2 v_1 + m_2^2 v_2$

(b) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \varepsilon$

(c) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

(d) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2^2u_2^2 + \varepsilon = \frac{1}{2}m_1^2v_1^2 + \frac{1}{2}m_2^2v_2^2$

AIPMT- 2015

Ans. (c) : Given,
Two particles of masses = m_1 and m_2
Initial velocities = u_1 and u_2

Total initial energy = $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

Since, after collision one particle absorb energy ε

$\therefore$ Total final energy = $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon$

From conservation of energy,

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon$$

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

611. A ball is dropped from height 20m.If coefficient of restitution is 0.9, what will be the height attained after first bounce

(a) 1.62m (b) 16.2m
(c) 18m (d) 14m

DCE-2007

Ans. (b) : Given that, h = 20 m
Coefficient of restitution, e = 0.9
Hence, height of a ball after collision,

$h' = (e)^2 \times h$
$h' = (0.9)^2 \times 20$
$h' = 16.2\ m$

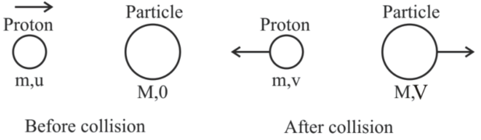
@apna_pdf

612. A proton in motion makes head on collision with an unknown particle at rest. If the collision is perfectly elastic and proton rebounds back with $\frac{4}{9}$ of its initial kinetic energy after collision, the mass of unknown particle is

(a) Equal to mass of proton
(b) Twice the mass of proton
(c) 3 times the mass of proton
(d) 5 times the mass of proton

AP EAMCET(Medical)-2016

Ans. (d) : According to the question,



We have,

$$\text{Final K.E. of proton} = \frac{4}{9}\times \text{Initial K.E of proton}$$

$$\frac{1}{2}mv^2 = \frac{4}{9}\times\frac{1}{2}mu^2 \qquad \text{....... (i)}$$

$$v = -\frac{2}{3}u \qquad \left\{\begin{array}{l}\because \text{particle \& proton}\\ \text{moves in opposite}\\ \text{direction}\\ \text{after collision}\end{array}\right\}$$

Using conservation of momentum,

$$mu = mv + MV = m\left(\frac{-2}{3}u\right) + MV$$

$$\therefore \qquad mu + \frac{2}{3}mu = MV$$

$$\frac{5}{3}mu = MV \qquad \text{...... (ii)}$$

Now, using conservation of energy for system,

$$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + \frac{1}{2}MV^2 = \left(\frac{4}{9}\times\frac{1}{2}mu^2\right) + \frac{1}{2}MV^2$$

$$\{\text{using eq}^n\text{(i)}\}$$

$$\frac{1}{2}mu^2\left(1-\frac{4}{9}\right) = \frac{1}{2}MV^2$$

$$\frac{5}{9}mu^2 = MV^2$$

$$\frac{5}{9}mu^2 = M\left(\frac{5mu}{3M}\right)^2 \qquad \{\text{using eq}^n\text{ (ii)}\}$$

$$\frac{5}{9}mu^2 = M\frac{25m^2u^2}{9M^2}$$

$$M = 5m$$

Hence, the mass of unknown particle is 5 times the mass of proton.

613. A 3 kg sphere makes an inelastic collision with another sphere at rest and they stick together after collision. After collision the composite mass moves with a speed of $\left(\frac{1}{4}\right)^{\text{th}}$ of the initial velocity of 3 kg sphere. The mass of second sphere is

(a) 12 kg
(b) 9 kg
(c) 6 kg
(d) 3 kg

AP EAMCET(Medical)-2012

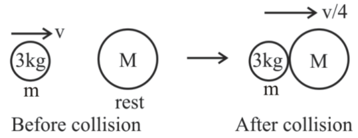
Ans. (b) : Given that, m = 3kg

Velocity before collision = v

Velocity after collision (v') = $\frac{1}{4}$v

Let M be the mass of second sphere.

According to the question,



Now, using conservation of momentum,

$$mv = (m+M)v'$$

$$3\times v = (3+M)\frac{v}{4}$$

$$M = 12 - 3$$

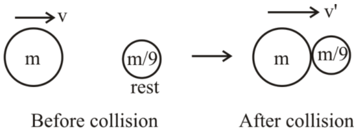
$$M = 9 \text{ kg}$$

614. A body of mass m strikes another body at rest of mass $\frac{m}{9}$. Assuming the impact to be inelastic the fraction of the initial kinetic energy transformed into heat during the contact is

(a) 0.1
(b) 0.2
(c) 0.5
(d) 0.64

AP EMCET(Medical)-2008

Ans. (a) :



Applying, conservation of momentum,

$$mv + \frac{m}{9}\times 0 = \left(m + \frac{m}{9}\right)v'$$

$$v' = \frac{9}{10}v$$

Now, energy transformed into heat,

$$\Delta K = K_i - K_f$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}\left(m+\frac{m}{9}\right).\left(\frac{9v}{10}\right)^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}\left(\frac{10m}{9}\right)\left(\frac{9v}{10}\right)^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}.\frac{9}{10}mv^2$$

$$= \frac{1}{2}\left(1-\frac{9}{10}\right)mv^2$$

$$\Delta K = \frac{1}{20}mv^2$$

@apna_pdf

Now,

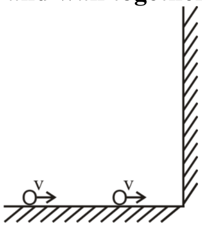
Fraction of kinetic energy-

$$\frac{\Delta K}{K_i}=\frac{\left(\frac{1}{20}mv^2\right)}{\frac{1}{2}mv^2}$$

$$\frac{\Delta K}{K_i}=\frac{2}{20}=\frac{1}{10}$$

$$\frac{\Delta K}{K_i}=0.1$$

615. Two balls of same mass each m are moving with same velocities v on a smooth surface as shown in figure. If all collisions between the masses and with the wall are perfectly elastic, the possible number of collisions between the bodies and wall together is



(a) 1 (b) 2

(c) 3 (d) infinity

AP EMCET(Medical)-2008

Ans. (c) : In elastic collision the velocity after the collision get interchange if mass of colliding particle are same.

There are three collision are possible –

1. The ball which is near to the wall collide with the ball and reverse its direction and move with same speed.

2. After that it would collide with the ball approaching it with same speed and exchange the velocities then the rear ball will move backwards with same speed but the ball which was ahead would again move toward wall with same speed.

3. The ball which is approaching to the wall again collide with wall and reverse it direction and move with same speed again forever.

616. The object at rest suddenly explodes into three parts with the mass ratio 2 : 1 : 1. The parts of equal mass move at right angles to each other with equal speeds. The speed of the third part after the explosion will be

(a) 2v (b) $v/\sqrt{2}$

(c) v/2 (d) $\sqrt{2}v$

AP EMCET(Medical)-2008

Ans. (b) : Resultant momentum of two equal masses,

$$P_1=\sqrt{(mv)^2+(mv)^2}=\sqrt{2}\,mv$$

Let, v' be the velocity of third part of mass 2m.

Now, according to the law of conservation of momentum, we have,

$$2mv'=\sqrt{2}\,mv$$

$$v'=\frac{v}{\sqrt{2}}$$

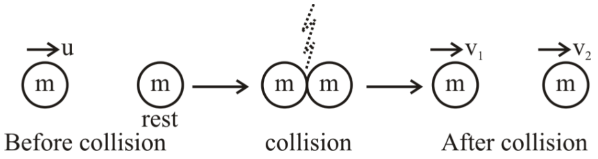
617. A sphere of mass m moving with a constant velocity u, coilides with another stationary sphere of same mass. If e is the coefficient of restitution, the ratio of the final velocities of the first and second spheres is

(a) $\frac{1+e}{1-e}$ (b) $\frac{1-e}{1+e}$

(c) $\frac{e}{1-e}$ (d) $\frac{1+e}{e}$

AP EAMCET(Medical)-2007

Ans. (b) :



Now, applying conservation of momentum,

$$mu = mv_1 + mv_2$$

$$u = v_1 + v_2 \quad \text{....(i)}$$

Now, coefficient of restitution, $e=\frac{v_2-v_1}{u}$

$$eu = v_2 - v_1 \quad \text{....(ii)}$$

Solving equation (i) and (ii), we get –

$$v_2=\frac{(e+1)u}{2}$$

$$v_1=\frac{(1-e)u}{2}$$

Therefore,

$$\frac{v_1}{v_2}=\frac{1-e}{1+e}$$

618. In two separate collisions, the coefficients of restitutions 'e_1' and 'e_2' are in the ratio 3:1. In the first collision the relative velocity of approach is twice the relative velocity of separation. Then the ratio between the relative velocity of approach and relative velocity of separation in the second collision is;

(a) 1:6 (b) 2:3

(c) 3:2 (d) 6:1

AP EAMCET-2007

AP EAMCET(Medical)-2006

Ans. (d) : Given,

$$e_1=\frac{1}{2} \quad \text{.... (i)}$$

$$\frac{e_1}{e_2}=\frac{3}{1} \quad \text{.... (ii)}$$

Putting the value of e_1 in equation (ii), we get-

$$\frac{\frac{1}{2}}{e_2}=\frac{3}{1}$$

$$e_2=\frac{1}{2}\times\frac{1}{3}=\frac{1}{6}=\frac{\text{relative velocity of sepration}}{\text{relative velocity of approach}}$$

Hence, required ratio = 6 : 1

@apna_pdf

619. Consider the following statements A and B and identify the correct answers:

A: Coefficient of restitution varies between 0 and 1.

B: In inelastic collision, the law of conservation of energy is satisfied

(a) A and B are true
(b) A and B are false
(c) A is true but B is false
(d) A is false but B is true

AP EAMCET(Medical)-2005

Ans. (a) : We know that, coefficient of restitution lies between –

$$0 \le e \le 1$$

- For elastic collision, e = 1
- For inelastic collision, $0 < e < 1$
- For perfectly elastic collision, e = 0

In inelastic collision, a part of the initial kinetic energy is converted into heat energy, but total energy remains conserved.

Hence, the law of conservation of energy is satisfied.

620. A body x with a momentum p collides with another identical stationary body y one dimensionally. During the collision y gives an impulse J to the body x. Then, the coefficient of restitution is:

(a) $\frac{2J}{p}-1$ (b) $\frac{J}{p}+1$
(c) $\frac{J}{p}-1$ (d) $\frac{J}{2p}-1$

AP EAMCET(Medical)-2004

Ans. (a) : We know that,

$$\text{Coefficient of restitution (e)} = \frac{(v_y)_f-(v_x)_f}{(v_x)_i-(v_y)_i} \quad \text{.... (i)}$$

$$\text{Now,} \quad (v_y)_f = \frac{(p_y)_f}{m} = \frac{J}{m}$$

for ‘x’: $(\Delta p)_x = -J$

$$(p_x)_f-(p_x)_i = -J$$

$$(p_x)_f = -J+(p_x)_i = -J+p$$

$$(v_x)_f = \frac{p-J}{m}$$

$$\therefore \quad e = \frac{\frac{J}{m}-\left(\frac{p-J}{m}\right)}{\frac{p}{m}-0} \quad \text{\{Using equation (i)\}}$$

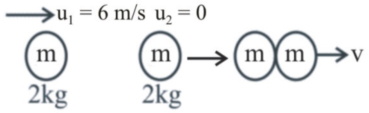
$$e = \frac{2J-p}{p}, \quad e = \frac{2J}{p}-1$$

621. A body of mass 2 kg moving with a velocity of 6 m/s strikes inelastically another body of same mass at rest. The amount of heat evolved during collision is:

(a) 36 J (b) 18J
(c) 9 J (d) 3J

AP EAMCET(Medical)-2002

Ans. (b) : Given, $m_1 = 2$ kg, $m_2 = 2$ kg, $u_1 = 6$ m/s



Before collision After collision

Appling conservation of linear momentum,

$$m_1u_1+m_2u_2 = (m_1+m_2)v$$

$$m_1u_1+0 = (m_1+m_2)\,v$$

$$v = \frac{2\times6}{2+2}$$

$$v = \frac{12}{4} = 3\text{m/s}$$

Heat evolved = loss in K.E. = Initial K.E. (E_i) – Final K.E. (E_f) ….(i)

$$E_i = \frac{1}{2}m_1u_1^2-\frac{1}{2}m_2u_2^2 \qquad [v_2=0]$$

$$= \frac{1}{2}\times2\times6^2-\frac{1}{2}\times2\times0$$

$$E_i = 36\text{J}$$

$$E_f = \frac{1}{2}(m_1+m_2)\times v^2 = \frac{1}{2}\times4\times3^2$$

$$E_f = 18\text{J}$$

From equation (i)

Heat evolve = $E_i - E_f$ = 36 – 18 = 18 J

622. A body ‘A’ experiences perfectly elastic collision, with a stationary body ‘B’. If after collision the bodies fly apart in the opposite directions with equal velocities, the mass ratio of ‘A’ and ‘B’ is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$
(c) $\frac{1}{4}$ (d) $\frac{1}{5}$

AP EAMCET(Medical)-2001

Ans. (b) : Let the mass of body A is m_A and mass of body B is m_B and body A and B have velocity $u_1 = u$ and $u_2 = 0$ respectively.

Final velocity of body A and B are $v_1 = v$ and $v_2 = -v$ respectively.

Appling principle of conservation of linear momentum–

$$m_Au_1+m_Bu_2 = m_Av_1+m_Bv_2$$

$$m_Au+0 = m_Av+m_B(-v) = (m_A-m_B)v \quad \text{....(i)}$$

Applying principle of conservation of K.E,

$$\frac{1}{2}m_Au^2 = \frac{1}{2}(m_A+m_B)v^2 \quad \text{....(ii)}$$

Dividing (ii) by (i) we get,

$$u = \frac{(m_A+m_B)v}{m_A-m_B}$$

$$\text{or} \quad \frac{u}{v} = \frac{m_A+m_B}{m_A-m_B} \quad \text{….(iii)}$$

From equation (i),

$$\frac{u}{v} = \frac{m_A-m_B}{m_A} \quad \text{…..(iv)}$$

@apna_pdf

From equation (iii) and (iv),

$$\frac{m_A + m_B}{m_A - m_B} = \frac{m_A - m_B}{m_A}$$

On solving we get,

$$\frac{m_A}{m_B} = \frac{1}{3}$$

623. In an elastic collision between two bodies, the physical quantity that is conserved is:

(a) kinetic energy
(b) momentum
(c) potential energy
(d) kinetic energy and momentum

AP EAMCET(Medical)-1999,1998

Ans. (d) : Both kinetic energy and momentum are conserved in an elastic collision.

624. A railway truck of mass m = 2 × 10^4 kg travelling at 0.5 ms^{-1} collides with another of half of it's mass moving in opposite direction with a velocity 0.4 ms^{-1}. If they collide each other then combined velocity is

(a) 0.1 ms^{-1} (b) 0.4 ms^{-1}
(c) 0.2 ms^{-1} (d) 0.5 ms^{-1}

EAMCET-1991

Ans. (c) : Given,
$m_1 = 2\times10^4$ kg, $m_2 = 1\times 10^4$ kg
$u_1 = 0.5$ m/s, $u_2 = -0.4$ m/s ,
Using the law of conservation of momentum,

$$m_1u_1 + m_2u_2 = (m_1+m_2)v$$
$$20{,}000\times0.5 + 10{,}000 \times (-0.4) = 30{,}000\ v$$
$$v = \frac{20{,}000\times0.5 - 10{,}000\times(0.4)}{30{,}000}$$
$$v = \frac{10{,}000 - 4{,}000}{30{,}000}$$
$$v = 0.2 ms^{-1}$$

625. A bullet of mass x moves with a velocity y, hits a wooden block of mass z at rest and gets embedded in it. After collision, if the wooden block with bullet in it moves, the velocity is

(a) $\frac{x}{x+z}y$ (b) $\frac{x+z}{x}y$
(c) $\frac{z}{x+z}y$ (d) $\frac{x+y}{z}y$

EAMCET-1993

Ans. (a) : Given data,
$m_1 = x$, $m_2 = z$
$u_1 = y$, $u_2 = 0$
By law of conservation of momentum,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2)v$$
$$(x) \times (y) + z \times 0 = (x + z)\ v$$
$$xy = v\ (x + z)$$
$$v = \frac{xy}{x+z}$$

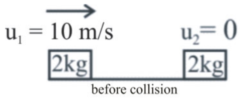
After collision, the wooden block with bullet moves with $\frac{xy}{x+z}$.

626. A 2 kg mass moving on a smooth frictionless surface with a velocity of 10 ms^{-1} hits another 2 kg mass kept at rest in an elastic collision. After collision, if they move together

(a) they travel with a velocity of 5 ms^{-1} in the same direction
(b) they travel with a velocity of 10 ms^{-1} in the same direction
(c) they travel with a velocity of 10 ms^{-1} in the opposite direction
(d) they travel in the opposite direction with a velocity of 5 ms^{-1}

EAMCET-1994

Ans. (a) : Given,
$m_1 = 2$ kg, $u_1 = 10\ ms^{-1}$
$m_2 = 2$ kg, $u_2 = 0$
Let the v_1 and v_2 be v.



According to law of conservation of momentum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$m_1u_1 + m_2u_2 = m_1v + m_2v \qquad [\therefore v_1 = v_2 = v]$$
$$m_1u_1 + m_1u_2 = (m_1 + m_2)v$$

Putting value of m, u and v, we get

$$2 \times 10 + 2 \times 0 = (2 + 2)v$$
$$20 = 4v$$
$$v = \frac{20}{4}$$
$$v = 5 m/s$$

They travel in same direction with a velocity of 5m/s.

627. A body of mass m_1 moving with a velocity 10 ms^{-1} collides with another body at rest of mass m_2. After collision the velocities of the two bodies are 2 ms^{-1} and 5 ms^{-1} respectively, along the direction of motion of m_1. The ratio $\frac{m_1}{m_2}$ is

(a) $\frac{5}{12}$ (b) $\frac{5}{8}$
(c) $\frac{8}{5}$ (d) $\frac{12}{5}$

EAMCET-2000

Ans. (b) : Let the initial velocity of body mass m1 and m2 be u1 and u2 respectively and final velocity be v_1 and v_2.
Given that,
$u_1 = 10\ ms^{-1}$
$u_2 = 0$
$v_1 = 2\ ms^{-1}$
$v_2 = 5\ ms^{-1}$
By the law of conservation of momentum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$10\ m_1 + m_2\times 0 = m_1 \times 2 + m_2 \times 5$$
$$10\ m_1 = 2m_1 + 5m_2$$
$$8\ m_1 = 5m_2$$
$$\frac{m_1}{m_2} = \frac{5}{8}$$

@apna_pdf

628. Two particles having position vectors $\vec{r}_1 = (3\hat{i}+5\hat{j})$ m and $\vec{r}_2 = (-5\hat{i}-3\hat{j})$ m are moving with velocities $\vec{v}_1 = (4\hat{i}+3\hat{j})$ ms^{-1} and $\vec{v}_2 = (a\hat{i}+7\hat{j})$ ms^{-1}. If they collide after 2 s, the value of a is

(a) 2 (b) 4
(c) 6 (d) 8

EAMCET-2003

Ans. (d) : Given that,

Time (t) = 20 sec.

$$\vec{r}_1 = (3\hat{i}+5\hat{j})\text{m},\ \vec{r}_2 = (-5\hat{i}-3\hat{j})\text{m}$$

$$\vec{v}_1 = (4\hat{i}+3\hat{j})\text{ms}^{-1},\ \vec{v}_2 = (a\hat{i}+7\hat{j})\text{ms}^{-1}$$

When two particles collide after 2 s they cover equal distance.

Then, $d_1 = d_2$

$$\vec{r}_1 + v_1 t = \vec{r}_2 + \vec{v}_2 t \quad (\therefore \text{distance} = \text{speed} \times \text{time})$$

$$(3\hat{i}+5\hat{j}) + 2(4\hat{i}+3\hat{j}) = (-5\hat{i}-3\hat{j}) + 2(a\hat{i}+7\hat{j})$$

$$3\hat{i}+5\hat{j}+8\hat{i}+6\hat{j} = -5\hat{i}-3\hat{j}+2a\hat{i}+14\hat{j}$$

$$11\hat{i}+11\hat{j} = (-5+2a)\hat{i}+11\hat{j}$$

Comparing both sides, we get –

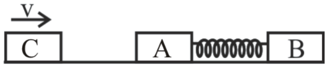
$$-5 + 2a = 11$$
$$2a = 16$$
$$a = 8$$

629. Two identical blocks A and B, each of mass m resting on smooth floor are connected by a light spring of natural length L and the spring constant k, with the spring at its natural length. A third identical block C (mass m) moving with a speed v along the line joining A and B collides with A. The maximum compression in the spring is proportional to

(a) $v\sqrt{\dfrac{m}{2k}}$ (b) $m\sqrt{\dfrac{v}{2k}}$
(c) $\sqrt{\dfrac{mv}{k}}$ (d) $\dfrac{mv}{2k}$

AP EAMCET-2003

Ans. (a) : According to law of conservation of linear momentum –



$$mv = (m+m)v'$$
$$mv = 2mv'$$
$$v' = \frac{v}{2}$$

By the law of conservation of energy,

K.E. of block C = K.E. of system + P.E. of system

$$\frac{1}{2}mv^2 = \frac{1}{2}(2m)v'^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}mv^2 = \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 + \frac{1}{2}kx^2 \qquad \left(\therefore v' = \frac{v}{2}\right)$$

$$\frac{1}{2}kx^2 = \frac{1}{4}mv^2$$

$$x = v\sqrt{\frac{m}{2k}}$$

630. A 2 kg ball moving at 24 ms^{-1} undergoes inelastic head-on collision with a 4 kg ball moving in the opposite direction at 48 ms^{-1}. If the coefficient of restitution is 2/3, their velocities in ms^{-1} after impact are

(a) –56, –8 (b) –28, –4
(c) –14, –2 (d) –7, –1

AP EAMCET-2004

Ans. (a) : Let u_1 and u_2 be the initial velocity of 2 kg and 4 kg ball.

Given, $m_1 = 2$ kg, $m_2 = 4$ kg, $u_1 = 24$ ms^{-1}, $u_2 = -48$ ms^{-1}

According to law of conservation of linear momentum, we get –

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2,$$
$$m_1u_1 + 2m_1(-2u_1) = m_1v_1 + 2m_1v_2,$$
$$-3u_1 = v_1 + 2v_2 \qquad \text{....(i)}$$

Coefficient of restitution (e) = $\dfrac{v_2 - v_1}{u_1 - u_2}$

$$v_2 - v_1 = e(u_1 - u_2)$$
$$v_2 - v_1 = e[(u_1 - (-2u_1)]$$
$$v_2 - v_1 = 3eu_1 \qquad \text{....(ii)}$$

Adding equation (i) and (ii), we get

$$3v_2 = 3u_1e - 3u_1$$

or $v_2 = u_1(e-1)$ ....(iii)

Putting the value of v_2 in equation (i), we get

$$v_1 = -u_1(1+2e) \qquad \text{....(iv)}$$

From equation (iii) and (iv), we get –

$$v_2 = 24\left(\frac{2}{3}-1\right) = -8 \text{ ms}^{-1}$$

$$v_1 = -24\left(1+2\times\frac{2}{3}\right) = -56\text{ms}^{-1}$$

631. For a system to follow the law of conservation of linear momentum during a collision, the condition is

(1) total external force acting on the system is zero.
(2) total external force acting on the system is finite and time of collision is negligible.
(3) total internal force acting on the system is zero.

(a) (1) only (b) (2) only
(c) (3) only (d) (1) or (2)

AP EAMCET-2006

Ans. (a) : Principle of conservation of linear momentum of a system remains constant (in magnitude and direction) if the external forces acting on the system is zero.

632. A ball is dropped from a height h on a floor of coefficient of restitution e. The total distance covered by the ball just before second hit is

(a) $h(1-2e^2)$ (b) $h(1+2e^2)$
(c) $h(1+e^2)$ (d) he^2

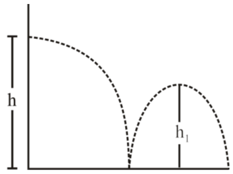
AP EAMCET-2008

@apna_pdf

Ans. (b) : Before the collision, we get
Potential energy = kinetic energy

$$mgh = \frac{1}{2}mv_1^2$$

$$v_1 = \sqrt{2gh}$$



After collision, velocity become v_2 .

Thus, coefficient of restitution (e) = $\frac{v_2}{v_1}$

Now, the height reached by the ball is given as –

$$mgh_1 = \frac{1}{2}mv_2{}^2$$

$$h_1 = \frac{1}{2}e^2 2h = e^2 h \qquad (\because v_2 = ev_1)$$

So, total distance covered before the second hit = $h+2h_1$

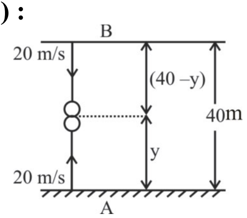
$$= h + 2e^2h = h(1 + 2e^2)$$

633. Two balls A and B, are thrown simultaneously, *A* vertically upward with a speed of 20 m/s from the ground and B vertically downward from a height of 40 m with the same speed and along the same line of motion. At what points do the two balls collide by taking acceleration due to gravity as 9.8 m/s^2?

(a) The balls with collide after 3s at a height of 30.2 m from the ground
(b) The balls with collide after 2s at a height of 20.1 m from the ground
(c) The balls with collide after 1s at a height of 15.1 m from the ground
(d) The balls with collide after 5s at a height of 20 m from the ground

NDA (II) 2016

Ans. (c) :



For downward motion of ball B,

$$40 - y = 20t + \frac{1}{2}gt^2 \qquad ....(i)$$

For upward motion of ball A,

$$y = 20\,t - \frac{1}{2}gt^2 \qquad ....(ii)$$

On adding equation (i) and (ii), we get

$$t = 1$$

From equation (ii), we get –

$$y = 20\times1 - \frac{1}{2}\times9.8\times1^2 = 15.1\text{ m}$$

$$y = 15.1\text{m}$$

634. A 4 kg mass and a 1 kg mass are moving with equal kinetic energies. The ratio of their momentum is

(a) 1 : 2
(b) 1 : 1
(c) 2 : 1
(d) 4 : 1

J&K CET- 1999

Ans. (c) :
Given that, mass (m_1) = 4kg, mass (m_2) = 1kg
Equal kinetic energy (K.E.) = $(K.E.)_1 = (K.E.)_2$
We know that,

$$\text{Kinetic Energy (K.E.)} = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

$$p = \sqrt{2mK.E.}$$

Then, $p_1 = \sqrt{2m_1K.E.}$ & $p_2 = \sqrt{2m_2K.E.}$

$$\therefore \quad \frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$$

$$p_1 : p_2 = 2 : 1$$

635. A rubber cord catapult has cross-sectional area 25mm^2 and initial length of rubber cord is 10 cm. It is stretched to 5cm and then released to project a missile of mass 5g. Taking $Y_{rubber}=5\times10^8$ Nm^{-2}, velocity of projected missile is–

(a) 20 ms^{-1}
(b) 100 ms^{-1}
(c) 250 ms^{-1}
(d) 200 ms^{-1}

BCECE-2011

Ans. (c) : Given,
Stretched length (ΔL) = 5 cm = 5×10^{-2} m
Cross sectional area (A) = 25 mm^2 = 25×10^{-6} m^2
Initial length of rubber cord (L) = 10 cm = 10×10^{-2} m
Mass of projected missile (m) = 5 g = 5×10^{-3} kg
Potential energy stored in the rubber cord catapult will be converted into kinetic energy of mass.

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{YA(\Delta L)^2}{L}$$

$$v = \sqrt{\frac{YA(\Delta L)^2}{mL}}$$

$$v = \sqrt{\frac{5\times10^8\times25\times10^{-6}\times(5\times10^{-2})^2}{5\times10^{-3}\times10\times10^{-2}}}$$

$$= \sqrt{\frac{5\times10^8\times25\times10^{-6}\times25\times10^{-4}}{50\times10^{-5}}}$$

$$= \sqrt{\frac{5\times625\times10^{-2}}{5\times10^{-4}}}$$

$$= \sqrt{625\times10^2} = 250\text{ m/s}$$

@apna_pdf

06. Rotational Motion

(a) Centre of Mass

1. Two objects P and Q initially at rest move towards each other under mutual force of attraction. At the instant when the velocity of P is v and that of Q is 2v, the velocity of centre of mass of the system is

(a) v (b) 3v
(c) 2v (d) 1.5v
(e) zero

Karnataka CET-2019
AIIMS-27.05.2018 (E)
Kerala CEE - 2015
APEMCET (Medical) - 2010
AMU- 2009
EAMCET-2008

Ans. (e) : Force on particle P is given by,

$$F_P = m_p a_p = \frac{m_P v}{t} \qquad \text{....(i)}$$

Similarly,

$$F_Q = m_Q a_Q = \frac{m_Q \times 2v}{t} \qquad \text{....(ii)}$$

Now,

$$F_P = F_Q$$

$$\frac{m_P v}{t} = \frac{m_Q \times 2v}{t}$$

$$m_P = 2m_Q$$

Velocity of centre of mass of the system,

$$v = \frac{m_P v_P - m_Q v_Q}{m_P + m_Q}$$

$$v = \frac{2m_Q v - m_Q \times 2v}{2m_Q + m_Q}$$

$$v = 0$$

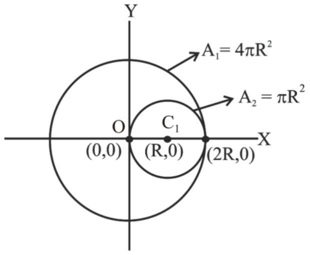
$\therefore$ Velocity of centre of mass of the system is zero.

2. A circular disc of radius R is removed from one end of a bigger circular disc of radius 2R. The centre of mass of the new disc is at a distance αR from the centre of the bigger disc. The value of α is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$
(c) $\frac{1}{4}$ (d) $\frac{1}{6}$

AP EAMCET (20.04.2019) Shift-1
JCECE-2008
UPSEE-2007

Ans. (b) : Let 'O' is the centre of circular disc of radius 2R and mass M, and C_1 is the centre of removed disc.
Let, σ = Surface mass density.



$$m_1 = \sigma A_1$$

$m_1 = \sigma.4\pi R^2$, (Where σ = Surface mass density)

$$m_2 = \sigma A_2$$

$$m_2 = \sigma \pi R^2$$

$$\therefore x_{CM} = \frac{m_1 x_1 - m_2 x_2}{m_1 - m_2}$$

$$x_{CM} = \frac{\sigma \cdot 4\pi R^2 \times 0 - \sigma \pi R^2 \cdot R}{\sigma 4\pi R^2 - \sigma \cdot \pi R^2} = \frac{-\sigma \pi R^3}{3\sigma \pi R^2}$$

$$x_{CM} = \frac{-R}{3}$$

Due to symmetry about x-axis

$$y_{CM} = 0$$

Then, $\vec{r}_{CM} = x_{CM}\hat{i} + y_{CM}\hat{j}$

$$\vec{r}_{CM} = \frac{-R}{3}\hat{i} + 0$$

$$|\vec{r}_{CM}| = \frac{R}{3} = \alpha R$$

On comparing,

$$\alpha = \frac{1}{3}$$

3. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i} + 2\hat{j} + \hat{k}$ and $-3\hat{i} - 2\hat{j} + \hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector:

(a) $\hat{i} - 2\hat{j} + \hat{k}$ (b) $-3\hat{i} - 2\hat{j} + \hat{k}$
(c) $-2\hat{j} + 2\hat{k}$ (d) $-2\hat{i} - \hat{j} + 2\hat{k}$

JEE Main-29.07.2022, Shift-I

Ans. (a) : Given, $m_1 = 1$kg, $m_2 = 3$kg

$$\vec{r}_1 = (\hat{i} + 2\hat{j} + \hat{k}), \qquad \vec{r}_2 = (-3\hat{i} - 2\hat{j} + \hat{k})$$

Centre of mass

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

@apna_pdf

$$\vec{r}_{cm} = \frac{1(\hat{i}+2\hat{j}+\hat{k})+3(-3\hat{i}-2\hat{j}+\hat{k})}{1+3}$$

$$= \frac{\hat{i}+2\hat{j}+\hat{k}-9\hat{i}-6\hat{j}+3\hat{k}}{4}$$

$$= \frac{-8\hat{i}-4\hat{j}+4\hat{k}}{4}$$

$$\vec{r}_{cm} = -2\hat{i}-\hat{j}+\hat{k}$$

$$|\vec{r}_{cm}| = \sqrt{(2)^2+(1)^2+(1)^2} = \sqrt{6}$$

(a) $|\hat{i}-2\hat{j}+\hat{k}| = \sqrt{1^2+2^2+1^2} = \sqrt{6}$

(b) $|-3\hat{i}-2\hat{j}+\hat{k}| = \sqrt{3^2+2^2+1^2} = \sqrt{14}$

(c) $|-2\hat{j}+2\hat{k}| = \sqrt{2^2+2^2} = 2\sqrt{2}$

(d) $|-2\hat{i}-\hat{j}+2\hat{k}| = \sqrt{2^2+1^2+2^2} = 3$

The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector is $\hat{i}-2\hat{j}+\hat{k}$.

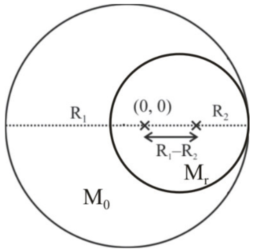
4. A circular portion of radius R_2 has been removed from one edge of a circular disc of radius R_1. The correct expression for the centre of mass for the remaining portion of the disc is–

(a) $-\frac{R_2^2}{R_1+R_2}$ (b) $-\frac{R_2^2}{R_1+R_2}$

(c) $\frac{R_2^2}{R_1+R_2}$ (d) $-\frac{R_1^2}{R_1+R_2}$

AP EAMCET-08.07.2022, Shift-II

Ans. (a) :



Let, M_0 = mass of circular plate

$M_0 = \rho\pi r^2 = \rho\pi(R_1)^2$

M_r = removed mass of circular plate.

$M_r = \rho\pi r^2 = \rho\pi(R_1)^2$.

Mass of remaining portion = $M_0 - M_r$

$= \rho\pi(R_1)^2 - \rho\pi(R_2)^2$.

$$x_{cm} = \frac{[\rho\pi(R_1)^2 \times 0]-[\rho\pi(R_2)^2 \times (R_1-R_2)]}{\rho[(R_1)^2-(R_2)^2]}$$

$$x_{cm} = \frac{-(R_2)^2(R_1-R_2)}{(R_1-R_2)(R_1+R_2)}$$

$$x_{cm} = \frac{-R_2^{\,2}}{R_1+R_2}$$

5. A solid circular disc of mass 100 kg rolls along a horizontal floor so that center of mass of the disc has a speed of 0.2 m s^{-1}. The absolute value of work done on the disc to stop it is

(a) 2 J (b) 3 J

(c) 2.5 J (d) 4 J

AP EAMCET-12.07.2022, Shift-I

Ans. (b) : Given,

mass of solid circular disc

m = 100 kg

v = 0.2 m/s

Total energy of the disc =

Translational kinetic energy + Rotational kinetic energy

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid circular disc-

$$I = \frac{1}{2}mr^2$$

$$\text{Total Energy} = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{1}{2}mr^2\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{4}mr^2\frac{v^2}{r^2} \qquad \left[\omega^2 = \frac{v^2}{r^2}\right]$$

$$= \frac{1}{2}mv^2\left(1+\frac{1}{2}\right)$$

$$= \frac{3}{4}mv^2 = \frac{3}{4}\times 100\times 0.2\times 0.2 = 3\text{ J}$$

Hence,

work done on the disc to stop it is equal to total energy

$$\boxed{\text{work done} = 3\text{J}}$$

6. The distance of centre of mass from end A of a one dimensional rod (AB) having mass density $\rho = \rho_0\left(1-\frac{x^2}{L^2}\right)$ kg/m and length L (in meter) is $\frac{3L}{\alpha}$ m. The value of α is ....(where x is the distance form end A)

JEE Main-28.07.2022, Shift-II

Ans. (8) : Given, $\rho = \rho_0\left(1-\frac{x^2}{L^2}\right)$ kg/m

$$x_{cm} = \frac{A\int_0^L \rho_0\left(1-\frac{x^2}{L^2}\right)x\,dx}{A\int_0^L \rho_0\left(1-\frac{x^2}{L^2}\right)dx}$$

$$x_{cm} = \frac{\int_0^L \left(x-\frac{x^3}{L^2}\right)dx}{\int_0^L \left(1-\frac{x^2}{L^2}\right)dx}$$

@apna_pdf

$$x_{cm} = \frac{\left[\frac{x^2}{2} - \frac{x^4}{4L^2}\right]_0^L}{\left[x - \frac{x^3}{3L^2}\right]_0^L}$$

$$x_{cm} = \frac{\left[\frac{L^2}{2} - \frac{L^4}{4L^2} - 0 - 0\right]}{\left[L - \frac{L^3}{3L^2} - 0 - 0\right]}$$

$$\vec{x}_{cm} = \frac{\left[\frac{L^2}{2} - \frac{L^2}{4}\right]}{\left[L - \frac{L}{3}\right]} = \frac{\frac{L^2}{4}}{\frac{2L}{3}} = \frac{3L}{8}$$

According to question centre of mass is given $\frac{3L}{\alpha}$ on comparing with calculated value of centre of mass we get, $\alpha = 8$

7. Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates (0, 0) cm and (x, 0) cm respectively. The block of 10 kg is moved on the same line though a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is

(a) 4 cm towards the 10 kg block
(b) 2 cm away from the 10 kg block
(c) 2 cm towards the 10 kg block
(d) 4 cm away from the 10 kg block

JEE Main-27.06.2022, Shift-I

Ans. (c) : Two masses m_1 and m_2 are kept in a straight line

$m_1 = 10$ kg, $m_2 = 30$ kg

The fist block is moved on the same line a distance of 6 cm.

$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

$$x_{cm} = \frac{10\times 6 + 30\times x_2}{10 + 30}$$

According to question centre of mass of the system remain unchanged $x_{cm} = 0$

$$x_{cm} = \frac{60 + 30x_2}{40}$$

$30x_2 = -60$

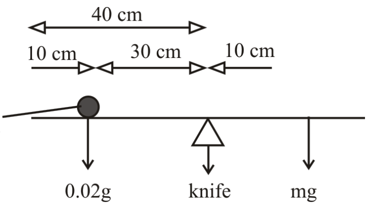
$x_2 = -2$ cm

So, the 30kg of block should be displaced 2cm to move towards 10 kg block.

8. A meter scale is balanced on a knife edge at its centre. When two coins, each of mass 10 g are put one on the top of the other at the 10.0 cm mark the scale is found to be balanced at 40.0 cm mark. The mass of the meter scale is found to be $x \times 10^{-2}$kg. The value of x is ____.

JEE Main-24.06.2022, Shift-I

Ans. (6)



Mass of coins added.

$m = 2 \times 10 = 20$ g

$d_1 = 40 - 10 = 30$ cm

$d_2 = 50 - 40 = 10$ cm

Equilibrium-

$m \times d_1 = M \times d_2$

$20 \times 30 = M \times 10$

$M = 60$ g

According to the question,

$M = x \times 10^{-2}$ kg

$60g = x \times 10^{-2}$ kg

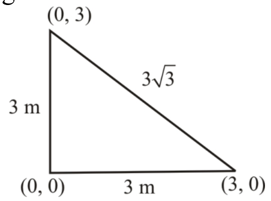
$60g = x \times 10^{-2} \times 1000$ g

$x = 6$

9. Three identical spheres each of mass M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 3 m each. Taking point of intersection of mutually perpendicular sides as origin, the magnitude of position vector of centre of mass of the system will be $\sqrt{x}$m. The value of x is

JEE Main-25.07.2022, Shift-II

Ans. (2) : According to the question, we can draw a figure which is given below:



$$\vec{r}_{cm} = \frac{M\left[(0\hat{i} + 0\hat{j}) + (3\hat{i} + 0\hat{j}) + \left(0\hat{i} + 3\hat{j}\right)\right]}{3M}$$

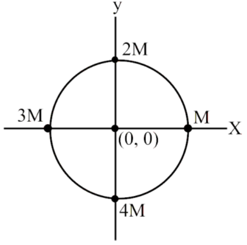
$$\vec{r}_{cm} = \frac{3\left[\hat{i} + \hat{j}\right]}{3}$$

$\vec{r}_{cm} = \hat{i} + \hat{j}$

$|\vec{r}_{cm}| = \sqrt{2} = \sqrt{x}$

$x = 2$

10. Four masses are arranged along a circle of radius 1 m as shown in the figure. The center of mass of this system of masses is at



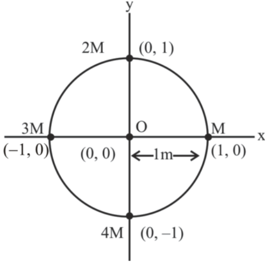
@apna_pdf

(a) $-\frac{1}{5}\hat{i}-\frac{1}{5}\hat{j}$ (b) $\frac{1}{5}\hat{i}+\hat{j}$

(c) $\hat{i}-\frac{1}{5}\hat{j}$ (d) $\frac{1}{5}\hat{i}+\frac{1}{5}\hat{j}$

TS EAMCET 18.07.2022, Shift-I

Ans. (a) : Given figure,



centre of mass of system

$$\vec{x}_{cm}=\frac{(M\times1)+(2M\times0)+(3M\times(-1))+(4M\times0)}{(M+2M+3M+4M)}$$

$$=\frac{M+(-3M)}{10M}=\frac{-2M}{10M}=\frac{-1}{5}$$

$$\vec{y}_{cm}=\frac{(M\times0)+(2M\times1)+(3M\times0)+(4M\times(-1))}{(M+2M+3M+4M)}$$

$$=\frac{2M-4M}{10M}=\frac{-2M}{10M}=\frac{-1}{5}$$

Position vector of centre of mass

$$\vec{r}_{cm}=\vec{x}_{cm}\hat{i}+\vec{y}_{cm}\hat{j}$$

$$\vec{r}_{cm}=-\frac{1}{5}\hat{i}+\left(\frac{-1}{5}\right)\hat{j}$$

$$\vec{r}_{cm}=-\frac{1}{5}\hat{i}-\frac{1}{5}\hat{j}$$

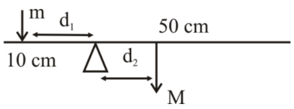
11. A metre stick is balanced on a knife edge at its centre. When four coins, each of mass 2g are put one on top of the other at 10.0 cm mark, the stick it found to be balanced at 46.0 cm mark. The mass of the metre stick is

(a) 66 g (b) 60 g

(c) 72 g (d) 18 g

TS EAMCET 19.07.2022, Shift-II

Ans. (c) :



Mass of coins added = 8g

$d_1 = 46 - 10 = 36$ cm

$d_2 = 50 - 46 = 4$ cm

$\tau_1 = md_1$

$\tau_2 = md_2$

For equilibrium conditions

$md_1 = md_2$

$8 \times 36 = M \times 4$

$$M=\frac{8\times36}{4}$$

M = 72 g

12. The centre of mass of an extended body on the surface of the earth and its centre of gravity

(a) Can never be at the same point

(b) Centre of mass coincides with the centre of gravity of a body if the size of the body is negligible as compared to the size (or radius) of the earth

(c) Are always at the same point for any size of the body

(d) Are always at the same point only for spherical bodies

Karnataka CET-2022

Ans. (b) : Centre of mass coincides with the centre of gravity of a body if size of body is negligible as compared to the size of the earth. For objects of sizes less than 100m centre of mass is very close with the centre of gravity of the body. But when the size of object increases. Its weight changes and distance between CM and CG increased.

13. A man weighing 70 kg is riding on a cart of mass 30 kg which moves along a level floor at a speed of 3ms^{-1}. If he runs on the cart so that his velocity relative to the cart is 4ms^{-1} in the direction opposite to the motion of the cart, the speed of centre of mass of the system is

(a) 0.3 ms^{-1} (b) 0.5 ms^{-1}

(c) 0.2 ms^{-1} (d) 0.1 ms^{-1}

(e) zero

Kerala CEE 04.07.2022

Ans. (c) :

Weight of the man, M = 70 kg

Weight of the cart, m = 30 kg

Velocity of the cart V_m= 3ms^{-1}

Relative velocity of man V_r = 4ms^{-1}

Velocity of man $V_M = V_r - V_m$

$= 4 - 3 = 1$ms^{-1}

Speed of the centre of mass of the system,

$$V_{cm}=\frac{m_1V_1+m_2V_2}{m_1+m_2}$$

$$V_{cm}=\frac{MV_M+mV_m}{M+m}$$

$$=\frac{70(-1)+30(3)}{70+30}$$

$$=\frac{-70+90}{100}=\frac{20}{100}=0.2\text{ms}^{-1}$$

14. Two objects of mass 10 kg and 20 kg respectively are connected to the two ends of a rigid rod of length 10 m with negligible mass. The distance of the center of the system from the 10 kg mass is

(a) 10 m (b) 5 m

(c) $\frac{10}{3}$m (d) $\frac{20}{3}$m

NEET-17.07.2022

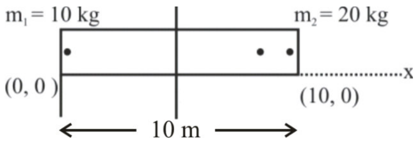
@apna_pdf

Ans. (d) : Given,

$m_1 = 10$ kg

$m_2 = 20$ kg

Length of rod = 10 m



$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

$$= \frac{(10\times0)+(20\times10)}{(20+10)}$$

$$x_{cm} = \frac{200}{30}$$

$$x_{cm} = \frac{20}{3}\text{m}$$

15. The X and Y coordinates of the three particles of masses m, 2m and 3m are respectively (0,0) (1,0) and (–2,0). The X-coordinate of the centre of mass of the system is

(a) $\frac{1}{3}$ (b) $\frac{2}{3}$

(c) $-\frac{1}{3}$ (d) $-\frac{2}{3}$

(e) $\frac{1}{6}$

Kerala CEE 2021

Ans. (d) : Centre of mass of the system,

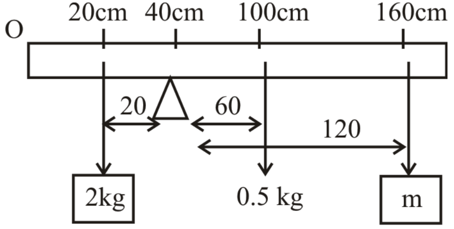
$$\vec{x}_{com} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$x_{com} = \frac{[m\times0]+[2m\times1]+[3m\times(-2)]}{[m+2m+3m]}$$

$$x_{com} = \frac{-4m}{6m}$$

$$x_{com} = \frac{-2}{3}$$

16. A uniform rod of length 200 cm and mass 500 g is balanced on a wedge placed at 40 cm mark. A mass of 2 kg is suspended from the rod at 20 cm and another unknown mass m is suspended from the rod at 160 cm mark as shown in the figure. Find the value of m such that the rod is in equilibrium. ($g = 10$ m/s^2)



(a) $\frac{1}{2}$kg (b) $\frac{1}{3}$kg

(c) $\frac{1}{6}$kg (d) $\frac{1}{12}$kg

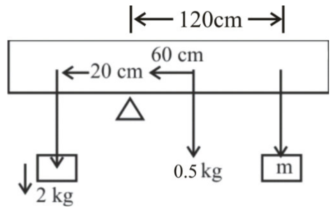
NEET- 2021

Ans. (d) : Given,

mass of rod = 500g = 0.5kg

Length of the rod = 200 cm

From figure,



By balancing torque

$$2g\times20 = 0.5\times g\times60 + mg\times120$$

$$40 = 30 + m \times 120$$

$$\boxed{m = \frac{10}{120} = \frac{1}{12}\text{kg}}$$

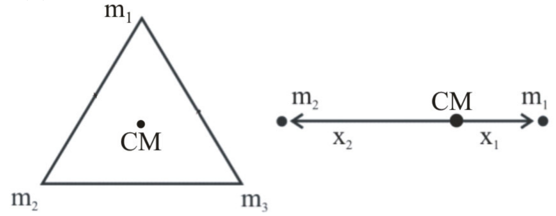
17. The sum of moments of all the particles in a system about its center of mass is always____

(a) Minimum (b) Zero

(c) Maximum (d) Infinite

AP EAMCET-19.08.2021, Shift-I

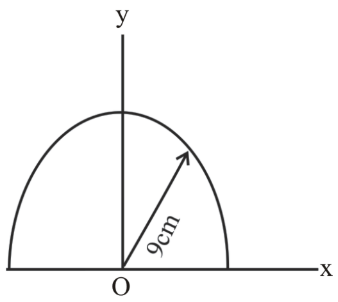
Ans. (b) : Moment of mass = Distance × Mass



$$MX_{cm} = \sum_{i=1}^{n} m_1X_c = \sum_{i=1}^{n} m_1X_i$$

$$\sum_{i=1}^{n} m_1(X_c - X_i) = 0$$

18. A homogenous semi circular plate of radius 9 cm placed at the origin as shown in the figure. The coordinate of center of mass is (Assume thickness is negligible)



(a) (0 cm, 6 cm) (b) (0 cm, 4.5 cm)

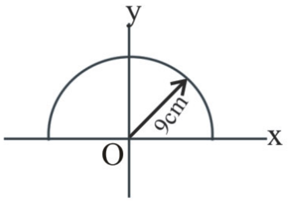
(c) (- 4.5 cm, 0 cm) (d) (- 4.5 cm, 4.5 cm)

TS EAMCET (Medical) 09.08.2021, Shift-I

@apna_pdf

Ans. (a) : Given symmetric about y – axis

$x_{axis} = 0$



$$r = \frac{\pi R \sin\theta}{3\theta}$$

$\because 2\theta = \pi$

$$\theta = \frac{\pi}{2}$$

$$r = \frac{\pi \times R \times \sin\frac{\pi}{2}}{3 \times \frac{\pi}{2}}$$

$$\boxed{r = \frac{2\pi R}{3\pi} = \frac{2R}{3}}$$

Centre of mass from the this point O

Co –ordinate $= \left(0, \frac{2\times 9}{3}\right)$

$= (0, 6)$

19. Centre of mass (C.M.) of three particles of masses 1 kg, 2 kg and 3 kg lies at the point (1, 2, 3) and C.M. of another system of particles of 3 kg and 2 kg lies at the point (–1, 3, –2). Where should we put a particle of mass 5 kg so that the C.M. of entire system lies at the C.M. of the first system?

(a) (3, 1, 8) (b) (0, 0, 0)

(c) (1, 3, 2) (d) (–1, 2, 3)

WB JEE 2021

Ans. (a) : As the definition of center of mass. One particle of mass (1 + 2 + 3) kg at (1,2,3) another particle of mass (2+3) kg at (–1, 3, – 2).

Third particle of mass 5 kg put at (x_3, y_3, z_3).

$m_1 = 6$kg,

$(x_1, y_1, z_1) = (1, 2, 3)$

$m_2 = 5$kg

$(x_2, y_2, z_2) = (-1, 3, -2)$

$m_3 = 5$ kg

$(x_3, y_3, z_3) = ?$

$(X_{cm}, Y_{cm}, Z_{cm}) = 1, 2, 3$

$$X_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$1 = \frac{6\times1 + 5\times(-1) + 5x_3}{6+5+5}$$

$5x_3 = 16 - 1$

$x_3 = 3$

Similarly, $y_3 = 1$ and $z_3 = 8$

20. Two particles of mass 5 kg and 10 kg respectively are attached to the two ends of a rigid rod of length 1 m with negligible mass.

The centre of mass of the system from the 5 kg particle is nearly at a distance of

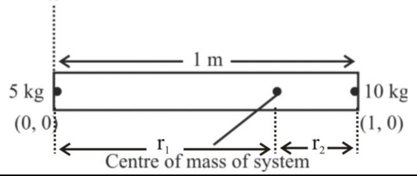
(a) 50 cm (b) 67 cm

(c) 80 cm (d) 33 cm

NEET (Sep.) -2020

Ans. (b) : Given, $m_1 = 5$kg, $m_2 = 10$kg

Distance between two masses be (d) = 1 m



Let suppose 5 kg at origin using equation -

$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

$$x_{cm} = \frac{5\times0 + 10\times1}{5+10}$$

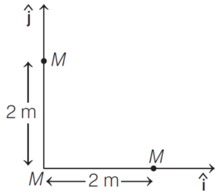
$$x_{cm} = \frac{10}{15}\text{m}$$

$$x_{cm} = \frac{10}{15}\times100\text{cm}$$

$$x_{cm} = \frac{1000}{15} = 66.67 \text{ cm}$$

$x_{cm} = 67$ cm

21. Three identical spheres, each of mass M, are placed at the corners of a right angle triangle with the mutually perpendicular sides equal to 2 m (see figure). Taking the point of intersection of the two mutually perpendicular sides as the origin, find the position vector of centre of mass.



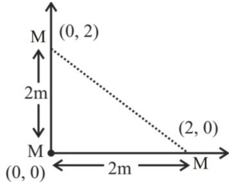
(a) $2(\hat{i} + \hat{j})$ (b) $(\hat{i} + \hat{j})$

(c) $\frac{2}{3}(\hat{i} + \hat{j})$ (d) $\frac{4}{3}(\hat{i} + \hat{j})$

NEET (Oct.) - 2020

Ans. (c) : Given,

Three identical sphere, each of mass M is placed at same distance 2m from origin



@apna_pdf

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$x_{cm} = \frac{M\times0 + M\times2 + M\times0}{M + M + M}$$

$$x_{cm} = \frac{2}{3}\frac{M}{M} = \frac{2}{3}$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3}$$

$$y_{cm} = \frac{M\times0 + M\times0 + M\times2}{3M}$$

$$y_{cm} = \frac{2}{3}$$

$$\vec{r}_{cm} = x_{cm}\hat{i} + y_{cm}\hat{j}$$

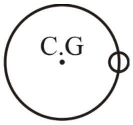
$$\Rightarrow \frac{2}{3}\hat{i} + \frac{2}{3}\hat{j} \Rightarrow \frac{2}{3}(\hat{i} + \hat{j})$$

22. The centre of mass of a ring is ______

(a) Outside the material of the body at the centre of symmetry
(b) Within the material of the body, at the centre of symmetry
(c) Along a tangent of the ring
(d) Perpendicular to edge of a ring

AP EAMCET-24.09.2020, Shift-I

Ans. (a) :



The centre of mass of a ring is outside the material of the body, at the centre of symmetry.

23. The center of mass on combining two masses m in and M (M > m) will be ______

(a) Towards m
(b) Towards M
(c) At the center of line joining m and M
(d) At centre of mass of m

AP EAMCET-24.09.2020, Shift-I

Ans. (b) : We know that,

Center of mass depend of mass distribution.

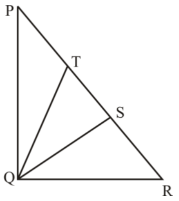
$$r_c = \left(\frac{mr + mR}{m + M}\right)$$

Given,

$M > m$

Therefore, the centre of the mass of the system will be towards M

24. Figure shows triangular lamina which can rotate about different axis of rotation. Moment of inertia is maximum about the axis

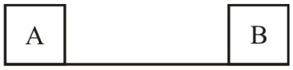


(a) QR (b) PR
(c) QS (d) PQ

MHT-CET 2020

Ans. (a) : In this figure we analysis that triangular lamina which can rotate about different axis of rotation moment of inertia is maximum about axis QR so option (a) is true.

25. Consider a two block system having masses M_A=3kg and M_B=2kg, as shown in the figure. If block A is pushed towards the centre of mass through a distance 200cm, by what distance should the block B be moved so as to keep the centre of mass at the same position.



(a) 200 cm (b) 300 cm
(c) 130 cm (d) 250 cm

TS EAMCET 29.09.2020, Shift-II

Ans. (b) : To keep the centre of mass at the same position, velocity of centre of mass is zero,

So,

$$\frac{m_1v_1 + m_2v_2}{m_1 + m_2} = 0$$

Where, v_1 and v_2 are the velocities of particles 1 and 2 respectively.

$$m_1\frac{dr_1}{dt} + m_2\frac{dr_2}{dt} = 0$$

$$v_1 = \frac{dr_1}{dt}, \quad v_2 = \frac{dr_2}{dt}$$

$$m_1dr_1 + m_2dr_2 = 0$$

dr_1 and dr_2 represent the change in displacement of particles.

Let, second body has been displaced by distance x

$$m_1(d) + m_2(x) = 0$$

$$m_1d = -m_2(x)$$

$$x = -\frac{m_1d}{m_2}$$

Here $m_1 = m_A = 3kg$
$m_2 = m_B = 2kg$
$d = 200$ cm

$$\therefore x = \frac{m_A}{m_B}d = \frac{3}{2}\times200 = 300\,cm$$

26. A uniform wire of length 'L' with centre of mass at the origin is lying along the x-axis. The wire is bent in the form of a circle such that its lowest point is at the origin. Then shift of centre of mass is

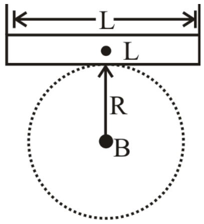
(a) $\frac{L}{\pi}$ (b) $\frac{2L}{\pi}$
(c) $\frac{L}{2\pi}$ (d) $\frac{L}{3\pi}$

TS EAMCET 28.09.2020, Shift-I

@apna_pdf

Ans. (c) : Given that,

Length of wire = L



The length of the wire equal to the circumference of the circle. As the circumference is the value of the boundary.

$$C = 2\pi R$$

Circumference is equal to length of wire $2\pi R = L$

$$R = \frac{L}{2\pi}$$

The centre of mass will be in terms of radius because the centre of mass shift by a value equal to that of the radius of circle.

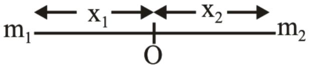
27. Consider a system of two particles having masses 'm_1' and 'm_2'. If the particle of mass m_1 is pushed towards the centre of mass of the particles through a distance 'd', by what distance particle of mass m_2 move so as to keep the centre of mass of particles at the original position ?

(a) $\frac{m_2}{m_1}\times d$ (b) $\frac{m_1}{(m_1 \times m_2)}\times d$

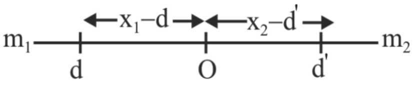
(c) $\frac{m_1}{m_2}\times d$ (d) d

MHT-CET 2020

Ans. (c) : If x_1 and x_2 are distance from center of mass, then



$$m_1x_1 = m_2x_2$$



$\therefore \quad m_1(x_1 - d) = m_2(x_2 - d')$

$m_1x_1 - m_1d = m_2x_2 - m_2d' \qquad (\because m_1x_1 = m_2x_2)$

$m_2x_2 - m_1d = m_2x_2 - m_2d'$

$m_1d = m_2d'$

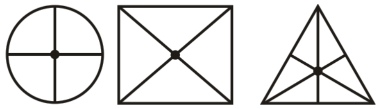
$\therefore \quad d' = \frac{m_1}{m_2}d$

28. Centre of mass is a point

(a) which is the geometric centre of a body.
(b) which is the origin of reference frame.
(c) where the whole mass of the body is supposed to be concentrated.
(d) from which distances of all particles are same.

MHT-CET 2020

Ans. (c) : Centre of mass of a body is a point at which the whole of the mass of the body supposed to be concentrated.



Center of mass

29. A point mass of 10 kg is placed at the centre of earth. The weight of the point mass is

(a) zero (b) 98 N
(c) 49 N (d) 10 N

AP EAMCET (21.09.2020) Shift-I

Ans. (a) : Given,

$m = 10\text{kg}$

Weight of the point mass,

$W = mg$

$\because$ Gravitational acceleration at the centre of earth, g = 0

$\therefore \quad W = m \times g = 10 \times 0 = 0$

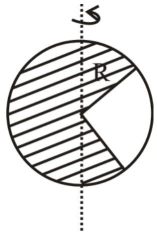
30. A disc of mass 'M' and radius 'R' is rotating about its own axis. If one quarter part of the disc is removed then new moment of inertia of the disc about the same axis is

(a) $\frac{2MR^2}{15}$ (b) $\frac{MR^2}{8}$

(c) $\frac{2MR^2}{13}$ (d) $\frac{3MR^2}{8}$

MHT-CET 2020

Ans. (d) :



Mass of the disc = M

Mass of quarter part of disc $= \frac{M}{4}$

Moment of inertia of disc $= \frac{1}{2}MR^2$

Mass of remain part of disc $= M - \frac{M}{4}$

$= \frac{3}{4}M$

Moment of inertia of remaining disc

$$= \frac{1}{2}\left(\frac{3}{4}M\right)R^2 = \frac{3}{8}MR^2$$

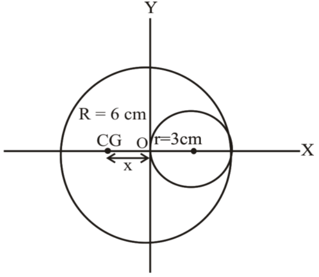
31. A circular hole of radius 3 cm is cut out from a uniform circular disc of radius 6 cm. The centre of the hole is at 3 cm, from the centre of the original disc. The distance of centre of gravity of the resulting flat body from the centre of the original disc is

@apna_pdf

(a) 0.5 cm (b) 1 cm
(c) 1.5 cm (d) 0.75 cm

TS-EAMCET-10.09.2020, Shift-1

Ans. (b) : Given, r = 3 cm, R = 6 cm
Let, m = Mass per unit area of the disc
$\therefore$ Mass of original disc = $\pi R^2 m$



Apply the formula of center of masses.

$$x_{CM} = \frac{m_1x_1 - m_2x_2}{m_1 - m_2} = \frac{m_1\times 0 - m_2\times 3}{\pi R^2 m - \pi r^2 m}$$

$$= \frac{-3m_2}{\pi m(R^2 - r^2)} = \frac{-3m\pi r^2}{\pi m\left(R^2 - r^2\right)} = \frac{-3r^2}{R^2 - r^2}$$

$$\therefore \quad x_{CM} = \frac{-3\times 3^2}{6^2 - 3^2} = -1\,\text{cm}$$

$$x_{CM} = -1\,\text{cm}$$

Thus, distance of centre of gravity of the resulting flat body from the centre of the original disc will be 1 cm left side.

32. Two atoms of oxygen are located at r_1 and r_2. Their centre of mass is at

(a) $r_1 + r_2$ (b) $\frac{r_1 - r_2}{2}$
(c) $\frac{r_1 + r_2}{2}$ (d) $r_1 - r_2$

AP EAMCET (22.09.2020) Shift-I

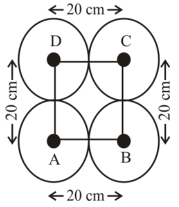
Ans. (c) : Let the mass of oxygen atom is m.
Then, $m_1 = m_2 = m$
Centre of mass of two oxygen atoms is given as,

$$x_{CM} = \frac{m_1r_1 + m_2r_2}{m_1 + m_2} = \frac{mr_1 + mr_2}{m + m}$$

$$x_{CM} = \frac{m\left(r_1 + r_2\right)}{2m}$$

$$x_{CM} = \frac{r_1 + r_2}{2}$$

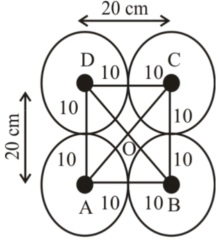
33. Four identical spheres each of radius 10m and equal mass 1kg each are placed on a horizontal surface touching each other, so that their centre are located at the vertices of a square of side 20cm. What is the distance of their centre of mass from the centre of either sphere?



(a) $20\sqrt{2}$ (b) $30\sqrt{2}$
(c) $10\sqrt{2}$ (d) $40\sqrt{2}$

AP EAMCET (21.09.2020) Shift-II

Ans. (c) : The given situation shown in the figure



Hence, centre of mass will be at intersection point of diagonals of square ABCD

$$\therefore \quad AC = BD = \sqrt{20^2 + 20^2} = 20\sqrt{2}$$

Distance from the centre of sphere-

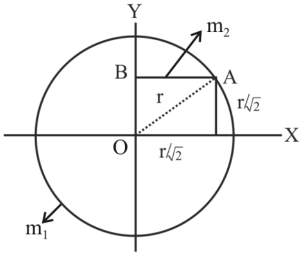
$$\therefore AO = BO = CO = DO = \frac{AC}{2} = \frac{BD}{2} = \frac{20\sqrt{2}}{2} = 10\sqrt{2}$$

34. A uniform circular disc has radius r. A square portion of diagonal r is cut from it. The centre of mass of the remaining disc from the centre of disc is

(a) $\frac{r}{2-4\pi}$ (b) $\frac{r}{3-3\pi}$
(c) $\frac{r}{2-5\pi}$ (d) $\frac{2r}{1-2\pi}$

AP EAMCET (21.09.2020) Shift-II

Ans. (a) : Let, m = mass per unit area
Then,
Mass of the circular disc (m_1) = $m\pi r^2$
mass of the square (m_2) = $m\left(\frac{r^2}{2}\right)$



$\because$ Centre of mass of circle is at O and centre of mass of square sheet is at r/2.

Now, $X_{cm} = \frac{m_1x_1 - m_2x_2}{m_1 - m_2}$

$$= \frac{m\pi r^2\times 0 - m\frac{r^2}{2}\times\frac{r}{2}}{m\pi r^2 - m\left(\frac{r^2}{2}\right)} = \frac{-m\left(\frac{r^2}{2}\right)\times\frac{r}{2}}{mr^2\left(\pi - \frac{1}{2}\right)}$$

$$= -\frac{r}{4}\times\frac{2}{(2\pi - 1)} = -\frac{r}{2(2\pi - 1)}$$

$$= \frac{r}{2-4\pi}$$

@apna_pdf

35. A thin disc and a thin ring, both have mass M and radius R. Both rotate about axis through their center of mass and are perpendicular to their surfaces at the same angular velocity. Which of the following is true?

(a) The ring has higher kinetic energy
(b) The disc has higher kinetic energy
(c) The ring and the disc have the same kinetic energy
(d) Kinetic energies of both the bodies are zero since they are not in linear motion

NDA (II) 2019

Ans. (a) : We know that,
Moment of inertia of the ring,

$$I_{ring} = MR^2$$

Moment of inertia of the disc,

$$I_{disc} = \frac{1}{2}MR^2$$

And also we know that,
Rotational kinetic energy

$$KE = \frac{1}{2}I\omega^2$$

According to the question angular velocity of both a thin ring and disc is the same. So, the kinetic energy depends on the moment of inertia.
Therefore, which having more moments of intertia will have more kinetic energy,

$$I_{ring} > I_{disc}$$

$$\therefore \quad KE_{ring} > KE_{disc}$$

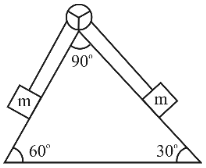
36. Assertion: The centre of mass of a proton and an electron, released from their respective positions remains at rest.
Reason: The centre of mass remains at rest, if no external force is applied.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

AIIMS-25.05.2019(E) Shift-2

Ans. (a) : Initially the electron and proton were at rest so their centre of mass will be rest. When they move toward each other under mutual attraction then centre of mass remains unaffected because external force on the system is zero.

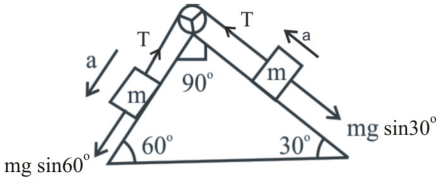
37. In the figure shown, the blocks have equal masses. Friction, mass of the string and the mass of the pulley are negligible. The magnitude of the acceleration of the centre of mass of the two blocks is (Acceleration due to gravity = g).



(a) $\left(\frac{\sqrt{3}-1}{\sqrt{2}}\right)g$
(b) $\frac{g}{2}$
(c) $\left(\sqrt{3}-1\right)g$
(d) $\left(\frac{\sqrt{3}-1}{4\sqrt{2}}\right)g$

AP EAMCET (23.04.2019) Shift-I

Ans. (d) :



Force equation for both the blocks

$$T - mg\sin 30^\circ = ma$$

$$T - \frac{mg}{2} = ma \quad .....(i)$$

$$mg\sin 60^\circ - T = ma$$

$$\frac{\sqrt{3}\,mg}{2} - T = ma \quad ......(ii)$$

Adding eq^n (i) and (ii) we get,

$$a = \left(\frac{\sqrt{3}-1}{4}\right)g$$

$\therefore$ Magnitude of the acceleration of centre of mass

$$a_{CM} = \left|\frac{ma_1 + ma_2}{m+m}\right|$$

$$a_{CM} = \left|\frac{\frac{(\sqrt{3}-1)g}{4}\hat{i} + \frac{(\sqrt{3}-1)g}{4}\hat{j}}{2}\right|$$

$$= \frac{g}{2}\sqrt{\left(\frac{\sqrt{3}-1}{4}\right)^2 + \left(\frac{\sqrt{3}-1}{4}\right)^2}$$

$$= \frac{g}{2} \times \sqrt{2} \times \frac{\sqrt{3}-1}{4}$$

$$a_{CM} = \left(\frac{\sqrt{3}-1}{4\sqrt{2}}\right)g$$

38. Three identical spheres each of diameter $2\sqrt{3}$ m are kept on a horizontal surface such that each sphere touches the other two spheres. If one of the sphere is removed, then the shift in the position of the centre of mass of the system is

(a) 12 m
(b) 1 m
(c) 2 m
(d) $\frac{3}{2}$m

AP EAMCET (21.04.2019) Shift-I

Ans. (b) : The centre of mass of the spheres is given by

$$x_{CM} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

@apna_pdf

As the spheres are identical

$$x_{CM} = \frac{m}{3m}\left(0 + 2\sqrt{3} + \sqrt{3}\right)$$

$$= \frac{3\sqrt{3}}{3} = \sqrt{3}$$

Similarly

$$y_{CM} = \frac{m}{3m}(y_1 + y_2 + y_3)$$

$$= \frac{0+0+3}{3} = 1$$

Center of mass $c_{CM} = \left(\sqrt{3}, 1\right)$

Hence, the centre of mass shifted by 1m in the y-direction.

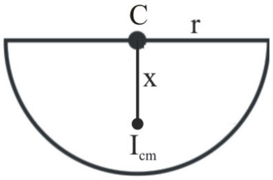
39. A semicircular plate of mass m has radius r and centre C. The centre of mass of the plate is at a distance x from its centre C. Its moment of inertia about an axis passing through its centre of mass and perpendicular to its plane is

(a) $\frac{mr^2}{2}$ (b) $\frac{mr^2}{4}$

(c) $\frac{mr^2}{2} + mx^2$ (d) $\frac{mr^2}{2} - mx^2$

AP EAMCET (20.04.2019) Shift-1

Ans. (d) :



From the parallel axis theorem,

$$I_c = I_{cm} + mx^2$$

$$I_{cm} = I_c - mx^2$$

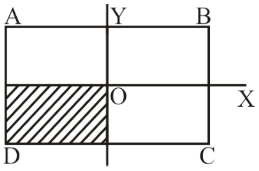
We know, moment of inertia of semicircle $(I_c) = \frac{mr^2}{2}$

Hence, moment of inertia of semicircular plate about an axis passing through its centre of mass and perpendicular to its plane is

$$I_{cm} = \frac{mr^2}{2} - mx^2$$

40. Figure shows a thin rectangular copper plate with its centre of mass at origin O and side AB = 2BC = 2m.

If a quarter part of the plate (shown as shaded is removed, the centre of mass of the remaining plate would lie at)

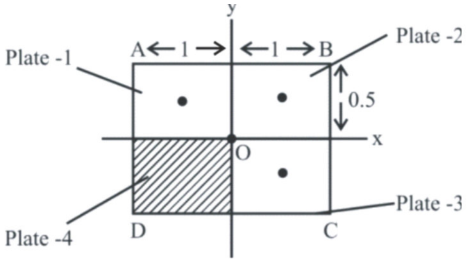


(a) $\frac{1}{12}m, \frac{1}{6}m$ (b) $\frac{1}{6}m, \frac{1}{12}m$

(c) $\frac{1}{3}m, \frac{1}{6}m$ (d) $\frac{1}{3}m, \frac{1}{2}m$

AMU-2018

Ans. (b) : From figure,



Given,

AB = 2m, 2BC = 2m

BC = 1m

Mass per unit area = σ

Then,

$$m_1 = m_2 = m_3 = (1 \times 0.5)\sigma = 0.5\sigma$$

If $(\bar{x}, \bar{y})$ be the position of centre of mass.

Then,

$$\bar{x} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$= \frac{0.5\sigma \times 0.5 + 0.5\sigma \times (-0.5) + 0.5\sigma \times 0.5}{0.5\sigma + 0.5\sigma + 0.5\sigma}$$

$$= \frac{0.5\sigma \times 0.5}{3 \times 0.5\sigma}$$

$$\bar{x} = \frac{1}{6}m$$

$$\bar{y} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3}$$

$$= \frac{0.5\sigma \times 0.25 + 0.5\sigma \times 0.25 + 0.5\sigma \times (-0.25)}{0.5\sigma + 0.5\sigma + 0.5\sigma}$$

$$= \frac{0.5\sigma \times 0.25}{3 \times 0.5\sigma}$$

$$\bar{y} = \frac{1}{12}m$$

Hence,

$$(\bar{x}, \bar{y}) = \frac{1}{6}m, \frac{1}{12}m$$

41. In the earth-moon system, if T_1 and T_2 are period of revolution of earth and moon respectively about the centre of mass of the system, then

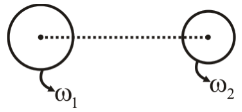
(a) $T_1 > T_2$ (b) $T_1 = T_2$

(c) $T_1 < T_2$ (d) Insufficient data

HP CET-2018

@apna_pdf

Ans. (b) :



$\therefore \quad \omega_1 = \omega_2 = \omega$

$$\frac{2\pi}{T_1} = \frac{2\pi}{T_2}$$

$\therefore \quad T_1 = T_2$

42. What is the distance of centre of mass of a half ring from centre if the ring has radius = 0.5 m?

(a) $\frac{1}{\pi}$ (b) $\frac{1}{3\pi}$

(c) $\frac{2}{3\pi}$ (d) $\frac{1}{2\pi}$

AIIMS-26.05.2018(E)

Ans. (a) : Given, R = 0.5 m

We know that,

Distance of centre of mass of half ring from center–

$$y = \frac{2R}{\pi} \qquad (\because R = 0.5 \text{ m})$$

$$= \frac{2 \times 0.5}{\pi}$$

$$y = \frac{1}{\pi}$$

43. Assertion: When you lean behind over the hind legs of the chair, the chair falls back after a certain angle.

Reason: Centre of mass lying outside the system makes the system unstable.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

AIIMS-27.05.2018(M)

Ans. (c) : The chair falls down after a certain angle because it becomes unstable as the normal reaction by ground on chair becomes zero.

There are several mechanical structures whose centre of mass lies outside its body but they are quite stable.

44. Two particles of masses in the ratio 1:2 are placed along a vertical line. The lighter particle is raised through a height of 9cm. To raise the centre of mass of the system by 2cm, the heavier particle should be

(a) Moved 1.5 cm downward

(b) Moved 2 cm upward

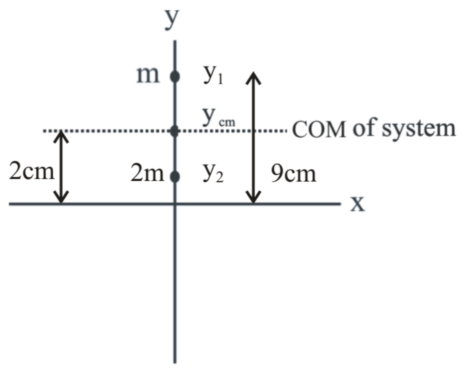
(c) Moved 1.5 cm upward

(d) Moved 2 cm downward

AP EAMCET (22.04.2018) Shift-II

Ans. (a) : Given; $y_1 = 9$ cm, $y_{cm} = 2$ cm, $y_2 = ?$

Let, initially particles are at origin, their masses are m and 2m



$$\therefore \quad \Delta y_{cm} = \frac{m_1\Delta y_1 + m_2\Delta y_2}{m_1 + m_2} = \frac{m \times 9 + 2m \times \Delta y_2}{3m}$$

$$2 = \frac{9 + 2 \times \Delta y_2}{3}$$

$$6 = 9 + 2 \times \Delta y_2$$

$$\Delta y_2 = -1.5 \text{ cm}$$

So, second particle must be moved 1.5 cm downward.

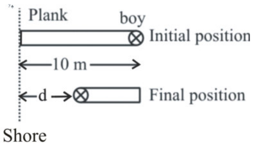
45. A 30 kg boy stands at the far edge of a floating plank, whose near edge is against the shore of a river. The plank is 10 m long and weighs 10 kg. If the boy walks to the near edge of the plank, how far from the shore does the plank move

(a) 7 m (b) 8 m

(c) 7.5 m (d) 15 m

TS-EAMCET-05.05.2018, Shift-1

Ans. (c):



Position of COM of the system remains same in the absence of external force.

$$\text{Initial} \quad x_{COM} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

(m_1=10kg, m_2= 30kg, x_1= 5m, x_2=10m)

$$= \frac{10 \times 5 + 30 \times 10}{10 + 30} = \frac{35}{4}$$

Let plank moves by distance d when boy changes his position,

Then,

$$x_{COM} = \frac{m_1x_1' + m_2x_2'}{m_1 + m_2}$$

$$\frac{35}{4} = \frac{10(5+d) + 30d}{10 + 30}$$

$$350 = 50 + 40d$$

$$d = 7.5 \text{ m}$$

@apna_pdf

46. The masses and positions (in rectangular coordinates) of four particles are as follows: 1kg at (a, a), 2kg at (–a, a), 3kg at (–a, –a) and 4kg at (a, – a). The position vector of the centre of mass of the system of four particles is

(a) $-4a\hat{i}$ (b) $-4a\hat{i}-4a\hat{j}$

(c) 0 (d) $-0.4a\hat{j}$

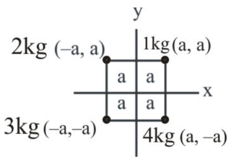
TS-EAMCET-05.05.2018, Shift-2

Ans. (d) : Given: $m_1 = 1$ kg , $m_2 = 2$ kg,

$m_3 = 3$ kg , $m_4 = 4$ kg

$$\vec{r}_1 = a\hat{i}+a\hat{j}\,,\ \vec{r}_2 = -a\hat{i}+a\hat{j}$$

$$\vec{r}_3 = -a\hat{i}-a\hat{j}\,,\ \vec{r}_4 = a\hat{i}-a\hat{j}$$



Position vector of centre of mass of system is,

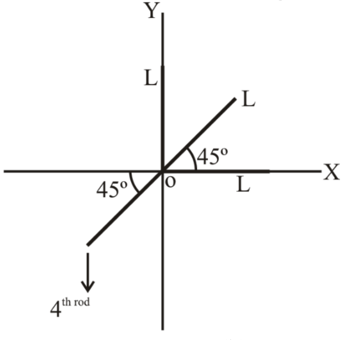
$$r_{COM} = \frac{m_1r_1+m_2r_2+m_3r_3+m_4r_4}{m_1+m_2+m_3+m_4}$$

$$= \frac{1(a\hat{i}+a\hat{j})+2(-a\hat{i}+a\hat{j})+3(-a\hat{i}-a\hat{j})+4(a\hat{i}-a\hat{j})}{10}$$

$$= \frac{0\hat{i}-4a\hat{j}}{10}$$

$$r_{COM} = -0.4a\hat{j}$$

47. Three identical uniform thin rods each of mass 'm' and length 'L' are arranged in the XY plane as shown in the figure. A fourth uniform thin rod of mass '3m' is placed as shown in the figure in the XY plane. The value of length of the fourth rod such that the centre of mass of all the four rods lies at the origin is



(a) 3L (b) 2L

(c) $\frac{L(\sqrt{2}+1)}{3}$ (d) $\frac{L(2\sqrt{2}+1)}{2}$

AP EAMCET-24.04.2017, Shift-II

Ans. (c) : Assume the length of fourth rod is L_1. It is given that the coordinate of the centre of mass of combined rod is at the origin.

Then,

$$X_{cm} = \frac{m_1x_1+m_2x_2+m_3x_3+m_4x_4}{m_1+m_2+m_3+m_4} = 0$$

$$m(0)+m\left(\frac{L}{2}\right)+m\left(\frac{L}{2\sqrt{2}}\right)+3m\left(\frac{-L_1}{2\sqrt{2}}\right) = 0$$

$$\frac{mL}{2}+\frac{mL}{2\sqrt{2}}-\frac{3mL_1}{2\sqrt{2}} = 0$$

$$\sqrt{2}L+L = 3L_1$$

$$\frac{(\sqrt{2}+1)L}{3} = L_1$$

48. The centre of mass of a system of three particles of masses 1g, 2g and 3g is at the origin of a co-ordinate system. If a particle of mass 4g and having position vector $\alpha(\hat{i}+2\hat{j}+3\hat{k})$ is added to the three particle system, then the centre of mass of the four-particle system becomes (1,2,3). The value of 'α' is

(a) $\frac{10}{3}$ (b) $\frac{5}{2}$

(c) $\frac{1}{2}$ (d) $\frac{2}{5}$

AP EAMCET-28.04.2017, Shift-I

Ans. (b) : Given that, the centre of mass of a system of three particles of masses 1g, 2g and 3g is at origin such that.

$$\frac{m_1\times x_1+m_2x_2+m_3x_3}{m_1+m_2+m_3} = 0$$

$$m_1x_1 + m_2x_2 + m_3x_3 = 0 \qquad .....(i)$$

Position vector of 4g particle = $\alpha(\hat{i}+2\hat{j}+3\hat{k})$

X-co-ordinate of the centre of the mass of system,

$$X_{cm} = \frac{m_1x_1+m_2x_2+m_3x_3+m_4x_4}{m_1+m_2+m_3+m_4}$$

Putting the value of $m_1x_1+m_2x_2 + m_3x_3$ from equation (i),

$$X_{cm} = \frac{0+4\times\alpha}{1+2+3+4} = \frac{4\alpha}{10}$$

$$1 = \frac{4\alpha}{10}$$

$$\alpha = \frac{10}{4}$$

$$\alpha = \frac{5}{2}$$

49. Three circular discs of same material and same thickness of radii r, 2r and 3r are placed on a horizontal plane such that their centres lie along a straight line. The radius of the middle disc is 2r and it touches the other two discs. The distance of the centre of mass of the system from the centre of the smaller disc is ______.

(a) 2r (b) 4 r

(c) 6 r (d) 8 r

AP EAMCET-26.04.2017, Shift-II

@apna_pdf

Ans. (c) : Distance of the centre of mass of system from the centre of smaller disc is-

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$x_{cm} = \frac{\sigma\pi r^2 \times 0 + 4\sigma\pi r^2 \times 3r + 8r \times 9\sigma\pi r^2}{\sigma\pi r^2 + 4\sigma\pi r^2 + 9\sigma\pi r^2}$$

$$x_{cm} = \frac{12r + 72r}{14} = \frac{84r}{14} = 6r$$

50. Two blocks of masses 10kg and 2Kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 12 ms^{-1} to the heavier block in the direction of the lighter block. The velocity of centre of mass is:

(a) 30 ms^{-1} (b) 10 ms^{-1}

(c) 20 ms^{-1} (d) 5 ms–1

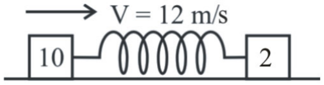
Assam CEE-2017

Ans. (b): Given: M_1 = 10 kg, M_2 = 2kg, V_1 = 12 m/s

$V_2 = 0$

$$V_{cm} = \frac{M_1V_1 + M_2V_2}{M_1 + M_2}$$

$$V_{cm} = \frac{10 \times 12 + 2 \times 0}{12} = 10 m/s$$



51. Two particles A and B (both initially at rest) start moving towards each other under a mutual force of attraction. At the instant, when the speed of A is *v* and the speed of B is 2*v*, the speed of the centre of mass is

(a) zero (b) v

(c) $\frac{3v}{2}$ (d) $-\frac{3v}{2}$

WB JEE 2017

Ans. (a) : At initial condition both the particles are at rest so speed of centre of mass is zero.

Centre of mass is affected only on application of external force.

As no external force is acting on the system, the centre of mass must be rest, hence speed of centre of mass is zero that is $v_{cm} = 0$.

52. Two balls are thrown simultaneously in air. The acceleration of the centre of mass of the two balls when in air :

(a) is equal to g (acceleration due to gravity)

(b) depends on the speeds of the two balls

(c) depends on the masses of the two balls

(d) depends on the direction of motion of the two balls

Karnataka CET-2017

Ans. (a) : Acceleration of centre of mass

$$a_{cm} = \frac{m_1a_1 + m_2a_2}{m_1 + m_2}$$

$\because \quad a_1 = a_2 = g$

$$\therefore \quad a_{cm} = \frac{m_1g + m_2g}{m_1 + m_2}$$

$$a_{cm} = \frac{g(m_1 + m_2)}{m_1 + m_2}$$

$$a_{cm} = g$$

Thus is only force acting on the balls is the force of gravity, so the acceleration of the centre of mass is equal to g.

53. In a two-particle system with particle masses m_1 and m_2, the first particle is pushed towards the centre of mass through a distance d, the distance through which second particle must be moved to keep the centre of mass at the same position is

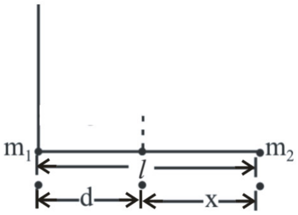
(a) $\frac{m_2d}{m_1}$ (b) d

(c) $\frac{m_1d}{(m_1 + m_2)}$ (d) $\frac{(m_1 + m_2)d}{m_1}$

(e) $\frac{m_1d}{m_2}$

Kerala CEE- 2013

Ans. (e) :



$$x_{cm} = \frac{m_1(0) + m_2(l)}{m_1 + m_2}$$

$$x_{cm} = \frac{m_2 l}{m_1 + m_2} \qquad \text{.......(i)}$$

$$x_{cm} = \frac{m_1(d) + m_2(l - x)}{m_1 + m_2} \qquad \text{...... (ii)}$$

On equating equation (i) & (ii) , we get

$$\frac{m_1d + m_2(l - x)}{m_1 + m_2} = \frac{m_2 l}{m_1 + m_2}$$

$$m_1d + m_2 l - m_2 x = m_2 l$$

$$m_1d = m_2x \Rightarrow x = \frac{m_1d}{m_2}$$

54. A system consists of 3 particles each of mass m located at points (1,1) (2,2) and (3,3). The coordinates of the centre of mass are

(a) (6, 6) (b) (3, 3)

(c) (1, 1) (d) (2, 2)

(e) (5, 5)

BITSAT-2010

Kerala CEE - 2009

@apna_pdf

Ans. (d) : Given, $m_1 = m_2 = m_3 = m$

$x_1 = 1$, $x_2 = 2$ and $x_3 = 3$

$y_1 = 1$, $y_2 = 2$, and $y_3 = 3$

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$x_{cm} = \frac{mx_1 + mx_2 + mx_3}{m + m + m} = \frac{x_1 + x_2 + x_3}{3}$$

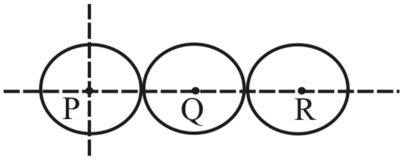
$$= \frac{1+2+3}{3} = \frac{6}{3} = 2$$

$$y_{cm} = \frac{my_1 + my_2 + my_3}{m + m + m} = \frac{y_1 + y_2 + y_3}{3}$$

$$= \frac{1+2+3}{3} = \frac{6}{3} = 2$$

Hence, the coordinates of the centre of mass are (2, 2).

55. Three identical spheres, each of mass 3 kg are placed touching each other with their centres lying on a straight line. The centres of the sphere are marked at P, Q and R respectively. The distance of centre of mass of system from P is



(a) $\frac{PQ + QR + PR}{3}$ (b) $\frac{PQ + PR}{3}$

(c) $\frac{PQ + QR + PR}{9}$ (d) $\frac{PQ + PR}{9}$

(e) $\frac{PQ + QR}{3}$

Kerala CEE – 2008, 2005

Ans. (b) :

The centre of mass of the given system consisting of three identical spheres of mass 3 kg each is

$$x_{cm} = \frac{M_P(x_P) + M_Q(x_Q) + M_R(x_R)}{M_P + M_Q + M_R}$$

$$x_{cm} = \frac{M(0) + M(PQ) + M(PR)}{M + M + M}$$

$$= \frac{M(PQ + PR)}{3M}$$

$$x_{cm} = \frac{PQ + PR}{3}$$

Hence, COM of the given system is $\frac{PQ + PR}{3}$

56. The distance between the centers of carbon and oxygen atoms in the carbon monoxide molecule is 1.130 Å. Locate the centre of mass of the molecule relative to the carbon atom :

(a) 5.428 Å (b) 1.130 Å

(c) 0.6457 Å (d) 0.3260 Å

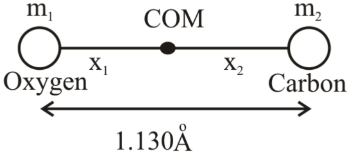
(e) none of these

Kerala CEE 2006

AIPMT - 1997

Ans. (c) : $m_1 = 16$ (Oxygen mass number)

$m_2 = 12$ (carbon mass number)



$m_2x_2 = m_1x_1$

$12x_2 = 16(1.130\times10^{-10} - x_2)$

$12x_2 = 16\times1.130\times10^{-10} - 16x_2$

$$x_2 = \frac{16\times1.13\times10^{-10}}{28}$$

$x_2 = 0.6457$ Å

Hence, the centre of mass (COM) of molecule relative to the carbon atom is 0.6457 Å.

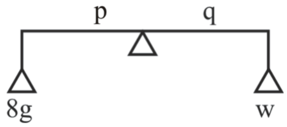
57. A body weighs 8g when placed in one pan and 18g when placed on the other pan of a false balance. If the beam is horizontal when both the pans are empty, then the true weight of the body is

(a) 15g (b) 13g

(c) 10g (d) 12g

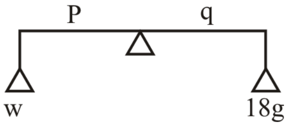
UPSEE - 2015

Ans. (d) :



$8Pg = wq$

$$P = \frac{wq}{8g} \quad ....(i)$$



$wP = 18qg$

$$P = \frac{18q}{w} \quad ....(ii)$$

On equating equations (i) and (ii), we get

$$\frac{wq}{8g} = \frac{18qg}{w}$$

$w^2 = 18\times8\times g^2$

$w = \sqrt{18\times8}\ g$

$w = 12g$

@apna_pdf

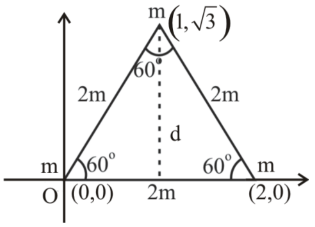
58. Three identical spheres of mass m each are placed at the corners of an equilateral triangle of side 2 m. Taking one of the corner as the origin, the position vector of the centre of mass is

(a) $\sqrt{3}\left(\hat{i}-\hat{j}\right)$ (b) $\frac{\hat{i}}{\sqrt{3}}+\hat{j}$

(c) $\frac{\hat{i}+\hat{j}}{3}$ (d) $\hat{i}+\frac{\hat{j}}{\sqrt{3}}$

UPSEE - 2014

Ans. (d) :



From figure,

$$\sin 60^\circ = d/2$$

$$\Rightarrow \quad d = 2\sin 60^\circ$$

$$= 2\times\frac{\sqrt{3}}{2}$$

$$= \sqrt{3}$$

The coordinates of centre of mass are-

$$\bar{x}=\frac{\sum m_i x_i}{\sum m_i}=\frac{m\times0+m\times1+m\times2}{m+m+m}=1$$

$$\bar{y}=\frac{\sum m_i y_i}{\sum m_i}=\frac{m\times0+m(\sqrt{3})+m\times0}{m+m+m}$$

$$\bar{y}=\frac{m\sqrt{3}}{3m}=\frac{1}{\sqrt{3}}$$

Hence, position vector of centre of mass is $\left(\hat{i}+\frac{\hat{j}}{\sqrt{3}}\right)$

59. Two blocks of masses 6kg and 4kg are placed on a frictionless surface and connected by a spring. If the heavier mass is given a velocity of 14ms^{-1} in the direction of lighter one, then the velocity gained by the centre of mass will be

(a) 7.4 ms^{-1} (b) 14 ms^{-1}

(c) 8.4 ms^{-1} (d) 10.0 ms^{-1}

UPSEE - 2009

Ans. (c) : Given:

$m_1 = 6$kg

$m_2 = 4$kg

$v_1 = 14$m/sec.

If the spring is massless, then no force will be exerted on the smaller mass i.e. Velocity of smaller mass will be zero.

Now, the velocity of center of mass (CM) is

$$v_{CM}=\frac{m_1v_1+m_2v_2}{m_1+m_2}$$

$$=\frac{6\times14+4\times0}{6+4}$$

$$v_{CM}=\frac{84}{10}=8.4\text{ m/sec}$$

Hence, the velocity of COM is 8.4m/sec

60. If the external forces acting on a system have zero resultant, the centre of mass:

(a) may move but not accelerate

(b) may accelerate

(c) must not move

(d) None of the above

UPSEE - 2005

Ans. (a) : Motion of the centre of mass,

$$M\vec{a}_{CM}=\vec{F}_{ext}$$

Then, $F_{ext}=0,\ \vec{a}_{CM}=0$

$$\vec{v}_{CM}=\text{constant}$$

If no external force act on a system the velocity of its centre of mass remains constant. Thus, the centre of mass move but not accelerate.

61. The centre of mass of three particles of masses 1kg, 2kg and 3kg is at (3, 3, 3) with reference to a fixed coordinate system. Where should a fourth particle of mass 4kg be placed, so that the centre of mass of the system of all particles shifts to a point (1, 1, 1)?

(a) (–1, –1, –1) (b) (–2, –2, –2)

(c) (2, 2, 2) (d) (1, 1, 1)

JCECE-2010

Ans. (b) : Suppose particle of 4kg mass is placed at point (x, y, z). Then the center of mass of 6kg (1kg + 2kg + 3kg) mass and 4 kg mass must lie at the point (1, 1, 1).

$$x_{CM}=\frac{6\times3+4\times x}{6+4}=1$$

$$10 = 18 + 4x$$

$$x = -2\text{m}$$

Similarly,

$$y_{CM}=\frac{6\times3+4\times y}{6+4}=1$$

$$10 = 18 + 4y$$

$$y = -2\text{m}$$

And for z-coordinate,

$$z_{CM}=\frac{6\times3+4\times z}{6+4}=1$$

$$10 = 18 + 4z$$

$$z = -2\text{m}$$

Hence, the fourth particle must be placed at the point (–2, –2, –2)

62. A small disc of radius 2 cm is cut from a disc of radius 6 cm. If the distance between their centers is 3.2 cm, what is the shift in the centre of mass of the disc?

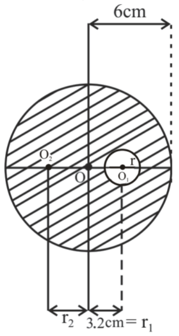
(a) 0.4 cm (b) 2.4 cm

(c) 1. 8 cm (d) 1.2 cm

JCECE-2007

@apna_pdf

Ans. (a) : Given, R = 6 cm , r = 2 cm



Let the mass per unit area = m

M = Mass of disc = $\pi R^2 m = \pi(6)^2 m = 36\pi m$

M_1 = Mass of removed disc = $\pi(r)^2 m = \pi(2)^2 m = 4\pi m$

M_2 = Mass of remaining portion = $M - M_1$

$= 36\pi m - 4\pi m = 32\pi m$

Center of removed disc $r_1 = 3.2$ cm

Center of remaining disc = r_2

Hence,

$$M \times 0 = M_1 r_1 + M_2 r_2$$

$$0 = M_1 r_1 + M_2 r_2$$

$$r_2 = \left[\frac{(-M_1 r_1)}{M_2}\right]$$

$$r_2 = \left[\frac{(-4\pi m) \times 3.2}{32\pi m}\right]$$

$$r_2 = -0.4 \text{ cm}$$

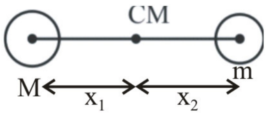
Negative sign indicate the shift from the centre.

63. The centre of mass of a system of two bodies of masses M and m, (M>m), separated by a distance d is

(a) Midway between the bodies
(b) Closer to the heavier body
(c) Closer to the lighter body
(d) At the centre of the heavier body

COMEDK 2014

Ans. (b) :



Let x_1 and x_2 be distance of centre of mass from the two bodies of masses M and m (M > m) respectively.

$$Mx_1 = mx_2$$

$$\frac{x_1}{x_2} = \frac{m}{M}$$

$\because \quad m < M$

$\therefore \quad \frac{x_1}{x_2} < 1 \Rightarrow x_1 < x_2$

Hence, the centre of mass is closer to the heavier body.

64. Assertion: If no external force acts on a system of particles, then the centre of mass will not move in any direction.

Reason: If net external force is zero, then the linear momentum of the system changes.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2011

Ans. (d) : We know that,

$$\vec{a}_{cm} = \frac{\vec{F}_{ext}}{M}$$

If $\quad \vec{F}_{ext} = 0$

Thus, $\vec{a}_{cm} = 0$

Thus, when no external force acts on a system of particles, it will move continuously with its initial velocity.

Now,

$$\frac{d\vec{P}}{dt} = \vec{F}_{ext}$$

$$\therefore \quad \frac{d\vec{P}}{dt} = 0 \qquad (\because \vec{F}_{ext} = 0)$$

$$\vec{P} = \text{Constant}$$

Hence, if no external force acts on the system, then linear momentum of the system is conserved.

So, the both Assertion and Reason is incorrect

65. Assertion : The position of centre of mass of a body depends upon shape and size of the body.

Reason: Centre of mass of a body lies always at the centre of the body.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2009

Ans. (c) : The centre of mass is the point where mass distribution is uniform in all direction. The position of centre of mass of a body depends on shape, size and distribution of the mass of the body.

Centre of mass of a body does not always lie on the centre of body. Only centre of mass of a uniform body lies always at geometric centre of the body.

Therefore correct answer is option (c).

66. Two particles of masses m_1 and m_2 ($m_1 > m_2$), initially at rest, moves towards each other under an inverse square law force of attraction. Pick out the correct statement about the centre of mass (CM) of the system

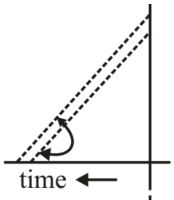
(a) The CM moves towards m_1
(b) The CM moves towards m_2
(c) The CM remains at rest
(d) The motion of CM is accelerated

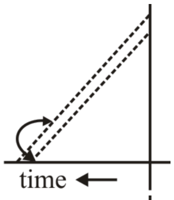
AIIMS-2009

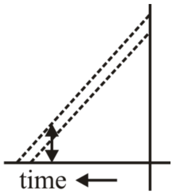
@apna_pdf

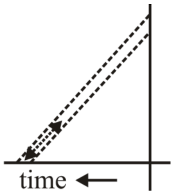
Ans. (c) : When no external force acts on the system and initially velocity of the centre of mass remains at rest because force of attraction is mutual.

67. A ladder leaned against a smooth wall and it is allowed to slip on a frictionless floor. Which figure represents the track of its centre of mass?

(a)


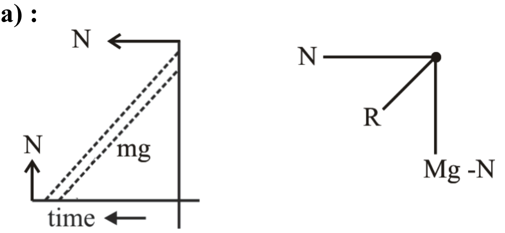
(b)


(c)


(d)


AIIMS-2005

Ans. (a) :



There are force on ladder Mg normal force from the floor and normal force from the wall.

So, the Net force will be in –ve due to Mg-N and –ve due to the normal from the wall.

Finally the rod will come to rest on the ground so we can see that it has moved down and in left direction.

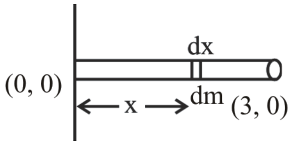
68. If linear density of a rod of length 3m varies as $\lambda = 2 + x$, then the position of the centre of gravity of the rod is :

(a) $\frac{7}{3}$m (b) $\frac{12}{7}$m

(c) $\frac{10}{7}$m (d) $\frac{9}{7}$m

BCECE-2005

Ans. (b) : Given, length of rod = 3 m , λ = 2 + x



Linear density of rod varies with distance

$$\frac{dm}{dx} = \lambda$$

$$dm = \lambda dx \qquad \text{....(i)}$$

Position of center of mass,

$$x_{CM} = \frac{\int dm \times x}{\int dm}$$

Putting the value of dm from equation (i), we get

$$= \frac{\int_0^3 (\lambda\, dx)x}{\int_0^3 \lambda\, dx} = \frac{\int_0^3 (2+x)x\, dx}{\int_0^3 (2+x)\, dx}$$

$$= \frac{\left[x^2 + \frac{x^3}{3}\right]_0^3}{\left[2x + \frac{x^2}{2}\right]_0^3} = \frac{9 + \frac{27}{3}}{6 + \frac{9}{2}} = \frac{12}{7}$$

$$x_{CM} = \frac{12}{7}\text{m}$$

69. Three identical spheres each of mass 1 kg are placed touching one another with their centres in a straight line. Their centres are marked as A, B, C, respectively. The distance of centre of mass of the system from A is

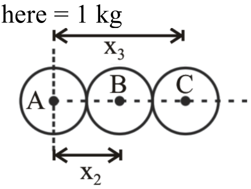
(a) $\frac{AB + AC}{2}$ (b) $\frac{AB + BC}{2}$

(c) $\frac{AC - AB}{3}$ (d) $\frac{AB + AC}{3}$

MHT-CET 2014

Ans. (d) : Given,

Mass of every sphere = 1 kg



The distance will measure from A,

$$\text{Centre of mass} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

Here, x is the center of mass from point A,

$$X_{COM} = \frac{1 \times 0 + 1 \times AB + 1 \times AC}{1 + 1 + 1}$$

$$X_{COM} = \frac{AB + AC}{3}$$

70. A cheetah, weighing 150 kg, chases a deer, weighing 30 kg, in a straight path. The speed of the cheetah is 20 m/s and that of the deer is 25 m/s. The approximate speed of the centre of mass of the pair is

(a) 21 m/s (b) 24 m/s

(c) 26 m/s (d) zero

J&K-CET-2012

Ans. (a) : Given, $m_1 = 150,\ m_2 = 30,\ v_1 = 20,\ v_2 = 25$

$$v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

$$= \frac{150 \times 20 + 30 \times 25}{150 + 30}$$

$$= \frac{3750}{180}$$

$$= 20.833 \text{ m/s}$$

$$\approx 21 \text{m/s}$$

@apna_pdf

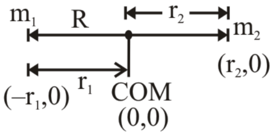
71. Two bodies of masses m_1 and m_2 are separated by a distance R. The distance of the centre of mass of the bodies from the mass m_1 is

(a) $\frac{m_2R}{m_1+m_2}$ (b) $\frac{m_1R}{m_1+m_2}$

(c) $\frac{m_1m_2}{m_1+m_2}R$ (d) $\frac{m_1+m_2}{m_1}R$

WB JEE 2016

Ans. (a) :



$R = r_1+r_2$ ....(i)

Mass moment about COM = 0

$m_2r_2 + (m_1)(-r_1) = 0$

$m_2r_2 - m_1r_1 = 0$

$m_2r_2 = m_1r_1$

$$r_2 = \frac{m_1r_1}{m_2}$$

Putting the value of equation ....(i)

$R = r_1 + r_2$

$$R = r_1 + \frac{m_1r_1}{m_2}$$

$$R = \frac{m_2r_1 + m_1r_1}{m_2}$$

$m_2R = m_2r_1 + m_1r_1$

$m_2R = r_1(m_2+m_1)$

$$r_1 = \frac{m_2R}{m_2+m_1}$$

72. A large number of particles are placed around the origin, each at a distance R from the origin. The distance of the centre of mass of the system from the origin is

(a) equal to R

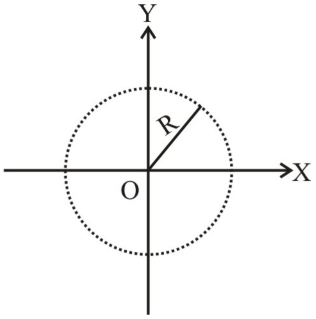
(b) less than equal to R

(c) greater than R

(d) greater than equal to R

WB JEE 2015

Ans. (b) :



The particles are all placed around the origin O at an equal distance of R from O. The focus of all the particles must from a circle.

The centre of mass of a system of particles depends on the masses of the particles and the distance of the particles from the origin.

The center of mass must therefore lie on the circle or inside it.

Here the distance of the particles from the origin remains the same as R. The masses of the particles can be different from each other or can be equal.

The centre of mass must therefore lie on the circle or inside it.

73. If we hollow the ball of pendulum and fill it with sand, what would be the effect of change on the center of mass ?

(a) It would distorted

(b) Its value will decrease only

(c) Its value will increase only

(d) Its value will first decrease and then increase

UP CPMT-2003

Ans. (d) : Its value will first decrease and then increase.

Reason:- Centre of mass completely depends on the Mass of constituent particles of the system.

74. The centre of mass of a body:

(a) Lies always outside the body

(b) may lie within, outside or on the surface of the body

(c) lies always inside the body

(d) lies always on the surface of the body

MP PET-2012

Ans. (b) : The location of centre of mass depend on the shape of body and the distribution of the mass.

The center of mass of a body can lie within or outside the body. For Example, center of mass of a uniform rod lies at its geometrical center which lies within the rod whereas centre of mass of a uniform ring lies at its geometrical center which lies outside the ring.

75. A body of mass M_1 = 4kg moves at 5m/s and another body of mass M_2 = 2kg moves at 10m/s. The kinetic energy of centre of mass is

(a) $\frac{200}{3}$ J (b) $\frac{500}{3}$ J

(c) $\frac{400}{3}$ J (d) $\frac{800}{3}$ J

JIPMER-2012

Ans. (c) : Given that,

$M_1 = 4$kg

$M_2 = 2$ kg

$V_1 = 5$ m/sec

$V_2 = 10$ m/sec

$$V_{CM} = \frac{M_1V_1 + M_2V_2}{M_1+M_2}$$

$$V_{CM} = \frac{4\times5+2\times10}{4+2}$$

$$V_{CM} = \frac{20+20}{6}$$

$$V_{CM} = \frac{40}{6}\,\text{m/sec}$$

@apna_pdf

$$\text{Kinetic energy} = \frac{1}{2}MV_{CM}^2 \qquad (\because M = M_1 + M_2)$$

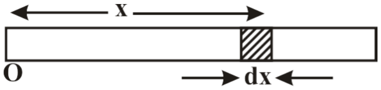
$$K.E = \frac{1}{2}\times 6\times\left(\frac{40}{6}\right)^2$$

$$K.E. = \frac{1}{2}\times 6\times\frac{1600}{36}$$

$$K.E. = \frac{800}{6}\,J$$

$$K.E = \frac{400}{3}\,J$$

76. The density of a rod having length *l* varies as ρ = c + Dx, where x is the distance from the left end. The centre of mass is

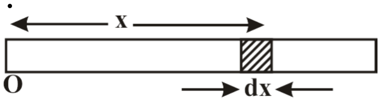


(a) $\dfrac{3cl+2Dl^2}{3(2c+D\,l^2)}$ (b) $\dfrac{2cl+3Dl^2}{2(4c+8l)}$

(c) $\dfrac{2cl+3\,Dl^2}{3(2c+l)}$ (d) $\dfrac{cl+Dl^2}{3(2c+Dl)}$

JIPMER-2015

Ans. (a) :



Let α = sectional area of rod

The mass of an element of length dx located at a distance x only from the left end is (c + Dx) αdx. The x–coordinate of the centre of mass is given by–

$$X_{cm} = \frac{\int_0^l x(\rho\alpha dx)}{\int_0^l \rho\alpha dx} = \frac{\int_0^l x(\rho dx)}{\int_0^l \rho dx}$$

We calculate–

$$I_1 = \int_0^l x(\rho dx)$$

$$= \int_0^l x(c+xD)dx$$

$$= \int_0^l (cx + x^2D)dx$$

$$\left[\frac{cx^2}{2}+\frac{x^3D}{3}\right]_0^l = \left[\frac{cl^2}{2}+\frac{l^3D}{3}\right] = \left[\frac{c}{2}+\frac{lD}{3}\right]l^2$$

$$I_1 = \frac{(3c+2lD)l^2}{6}$$

Now-

$$I_2 = \int_0^l \rho dx$$

$$I_2 = \int_0^l (c+Dx)dx$$

$$I_2 = \left[cx + \frac{x^2D}{2}\right]_0^l$$

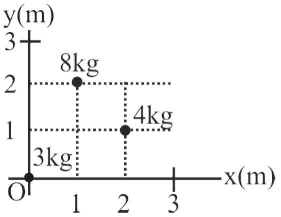
$$I_2 = \left[cl + \frac{l^2}{2}D\right] = \left[\frac{2lc+l^2D}{2}\right] = l\left[\frac{2c+lD}{2}\right]$$

$$\therefore \quad X_{cm} = \frac{I_1}{I_2}$$

$$X_{cm} = \frac{(3c+2lD)l^2}{6}\times\frac{2}{(2c+lD)l}$$

$$X_{cm} = \frac{(3c+2lD)l}{3(2c+lD)}$$

77. Find the x and y coordinates of the centre of mass of the three particles system (as shown).



(a) 1.0 m, 1.0 m (b) 1.3 m, 0.9 m

(c) 1.1 m, 1.3 m (d) 1.3 m, 1.1 m

AMU-2016

Ans. (c): Center of mass is a position defined relative to an object or system of objects.

For x – axis

$$x_{cm} = \frac{M_1X_1 + M_2X_2 + M_3X_3 + ...}{M_1 + M_2 + M_3 + ...}$$

For y = axis-

$$y_{cm} = \frac{M_1Y_1 + M_2Y_2 + M_3Y_3 + ...}{M_1 + M_2 + M_3 + ...}$$

Given data,

$(x_1, y_1) = (0,0)$, $m_1 = 3$ kg

$(x_2, y_2) = (1, 2)$, $m_2 = 8$ kg

$(x_3, y_3) = (2, 1)$, $m_3 = 4$ kg

Now, the coordinate of the center of mass

$$X_{cm} = \frac{X_1M_1 + X_2M_2 + X_3M_3}{M_1 + M_2 + M_3}$$

$$X_{cm} = \frac{0\times3 + 1\times8 + 2\times4}{3+8+4} = \frac{16}{15} = 1.0667$$

$$X_{cm} = 1.0667 \approx 1.1$$

$$Y_{cm} = \frac{Y_1M_1 + Y_2M_2 + Y_3M_3}{M_1 + M_2 + M_3}$$

$$= \frac{0\times3 + 8\times2 + 1\times4}{3+8+4} = 1.3$$

So, X and Y coordinates of centre of mass is 1.1 and 1.3 respectively.

@apna_pdf

78. A bomb travelling in a parabolic path under the effect of gravity, explodes in mid-air. The centre of mass of the fragments will

(a) move vertically upwards and then vertically downwards
(b) move vertically downwards
(c) move in irregular path
(d) move in the parabolic path the unexploded bomb would have travelled

EAMCET-1993

Ans. (d) : Since the unexploded bomb was travelling in a parabolic path, so the center of mass of the fragments will also move in the parabolic path because there is no external force acting on the bomb during explosion.

$F_{ext} = 0 \quad \Rightarrow ma_{cm} = 0 \quad \Rightarrow V_{cm} = \text{constant}$

79. Two particles of mass 1 kg and 3 kg have position vectors ($2\hat{i}+3\hat{j}+4\hat{k}$) and ($-2\hat{i}+3\hat{j}-4\hat{k}$) respectively. The centre of mass, has a position vector

(a) $\hat{i}+3\hat{j}-2\hat{k}$
(b) $-\hat{i}-3\hat{j}-2\hat{k}$
(c) $-\hat{i}+3\hat{j}+2\hat{k}$
(d) $-\hat{i}+3\hat{j}-2\hat{k}$

EAMCET-1999

Ans. (d) : Let $m_1 = 1$ kg, $m_2 = 3$kg

$$\vec{r}_1 = 2\hat{i}+3\hat{j}+4\hat{k} \text{ and } \vec{r}_2 = -2\hat{i}+3\hat{j}-4\hat{k}$$

$$\therefore \vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2}$$

$$= \frac{1\left(2\hat{i}+3\hat{j}+4\hat{k}\right)+3\left(-2\hat{i}+3\hat{j}-4\hat{k}\right)}{1+3}$$

$$\boxed{\vec{r}_{CM} = -\hat{i}+3\hat{j}-2\hat{k}}$$

80. The velocities of three particles of masses 20 g, 30g and 50g are $10\hat{i}$, $10\hat{j}$ and $10\hat{k}$ respectively. The velocity of the centre of mass of the three particles is

(a) $2\hat{i}+3\hat{j}+5\hat{k}$
(b) $10\left(\hat{i}+\hat{j}+\hat{k}\right)$
(c) $20\hat{i}+30\hat{j}+5\hat{k}$
(d) $2\hat{i}+30\hat{j}+50\hat{k}$

EAMCET-2001

Ans. (a) : Let m_1, m_2, m_3 be 20g, 30g, 50g respectively and $\vec{V}_1, \vec{V}_2, \vec{V}_3$ be $10\hat{i}, 10\hat{j}, 10\hat{k}$ respectively

Then, $$\vec{V}_{CM} = \frac{m_1\vec{V}_1 + m_2\vec{V}_2 + m_3\vec{V}_3}{m_1+m_2+m_3}$$

$$= \frac{20\times10\hat{i}+30\times10\hat{j}+50\times10\hat{k}}{20+30+50}$$

$$= \frac{200\hat{i}+300\hat{j}+500\hat{k}}{100}$$

$$\boxed{\vec{V}_{CM} = 2\hat{i}+3\hat{j}+5\hat{k}}$$

81. Particles of masses m, 2m, 3m .... nm gram are placed on the same line at distance l, $2l$, $3l$ .... nl cm from a fixed point. The distance of centre of mass of the particles from the fixed point in cm is

(a) $\frac{(2n+1)l}{3}$
(b) $\frac{l}{n+1}$
(c) $\frac{n(n^2+1)l}{2}$
(d) $\frac{2l}{n(n^2+1)}$

EAMCET-2002

Ans. (a) :
Center of mass for 'n' particles

$$= \frac{m_1x_1+m_2x_2+.....+m_nx_n}{m_1+m_2+m_3+......+m_n}$$

$$\text{COM} = \frac{m\times l+2m\times 2l+3m\times 3l+.........+nm\times nl}{m+2m+3m+..........+nm.}$$

$$= \frac{ml\left(1^2+2^2+3^2+......+n^2\right)}{m\left(1+2+3+......+n\right)}$$

$$= \frac{l\,\frac{n\left(n+1\right)\left(2n+1\right)}{6}}{\frac{n\left(n+1\right)}{2}}$$

$$\boxed{\text{COM} = \frac{l\left(2n+1\right)}{3}}$$

82. Two objects of masses 200 g and 500 g possess velocities $10\hat{i}$ ms^{-1} and $\left(3\hat{i}+5\hat{j}\right)$ms^{-1} respectively. The velocity of their centre of mass in ms^{-1} is

(a) $5\hat{i}-25\hat{j}$
(b) $\frac{5}{7}\hat{i}-25\hat{j}$
(c) $5\hat{i}+\frac{25}{7}\hat{j}$
(d) $25\hat{i}-\frac{5}{7}\hat{j}$

EAMCET-2003

Ans. (c) : Given:

$m_1 = 200$g, $m_2 = 500$ g.

$\vec{V}_1 = 10\hat{i}$ m/s, $\vec{V}_2 = \left(3\hat{i}+5\hat{j}\right)$m/s.

$$\therefore \vec{V}_{CM} = \frac{m_1\vec{V}_1+m_2\vec{V}_2}{m_1+m_2}$$

$$= \frac{0.2\left(10\hat{i}\right)+0.5\left(3\hat{i}+5\hat{j}\right)}{0.2+0.5} = \frac{3\cdot5\hat{i}+2\cdot5\hat{j}}{0.7}$$

$$\vec{V}_{CM} = 5\hat{i}+\frac{25}{7}\hat{j}$$

83. Two particles of equal mass have velocities $\vec{v}_1 = 4\hat{i}$ ms^{-1} and $\vec{v}_2 = 4\hat{j}$ ms^{-1}. First particle has an acceleration $\vec{a}_1 = \left(5\hat{i}+5\hat{j}\right)$ while the acceleration of the other particle is zero. The centre of mass of the two particles moves in a path of

@apna_pdf

(a) straight line (b) parabola
(c) circle (d) ellipse

EAMCET-2004

Ans. (a) :
Velocity of the center of mass of the particles system.

$$\vec{V}=\frac{m_1\vec{V_1}+m_2\vec{V_2}}{m_1+m_2}=\frac{\vec{V_1}+\vec{V_2}}{2}\{\because m_1=m_2\}$$

$$=\frac{4\hat{i}+4\hat{j}}{2}=\left(2\hat{i}+2\hat{j}\right)m/s$$

Now, $\tan\theta=\frac{y}{x}=\frac{2}{2}=1$

$$\Rightarrow \boxed{\theta=45^\circ}$$

Now, $\vec{a}_{CM}=\frac{m_1\vec{a}_1+m_2\vec{a}_2}{m_1+m_2}=\frac{\vec{a}_1+\vec{a}_2}{2}\{\because m_1=m_2\}$

$$=\frac{5\hat{i}+5\hat{j}+0}{2}=\frac{5}{2}\left(\hat{i}+\hat{j}\right)m/s^2$$

Now, $\tan\theta=\frac{y}{x}=\frac{5/2}{5/2}=1$

$$\Rightarrow \boxed{\theta=45^\circ}$$

As it is clear that the direction of $\vec{V}_{CM}$ and $\vec{a}_{CM}$ are same, therefore path of COM will be a straight line.

84. The centre of mass of three particles of masses 1 kg, 2 kg and 3 kg is located at (2, 2, 2). The position of the fourth mass of 4 kg to be placed in the system as that the new centre of mass is at (0, 0, 0) is

(a) (–3, –3, –3) (b) (–3, 3, –3)
(c) (2, 3, –3) (d) (2, –2, 3)

EAMCET-2005

Ans. (a) : Let (x_1, y_1, z_1), (x_2, y_2, z_2) and (x_3, y_3, z_3) be the coordinates of masses 1 kg, 2 kg & 3 kg. Also, let the co-ordinate of centre of mass of the 4 kg mass be (x_4, y_4, z_4).

We know, $x_{CM}=\frac{m_1x_1+m_2x_2+m_3x_3}{m_1+m_2+m_3}$

$$2=\frac{1\times x_1+2x_2+3x_3}{1+2+3}$$

$$x_1+2x_2+3x_3=12 \quad .....(i)$$

Now, for x coordinate of new center of mass that shifts to 0.

$$0=\frac{1x_1+2x_2+3x_3+4x_4}{1+2+3+4}$$

$$x_1+2x_2+3x_3+4x_4=0 \quad ......(ii)$$

from equation (i) & (ii), we get

$$12+4x_4=0$$

$x_4=-3$

Similarly, $y_4=-3$ and $z_4=-3$

Therefore, 4 kg mass should be placed at (–3, –3, –3)

85. Two bodies of 6 kg and 4 kg masses have their velocity $(5\hat{i}-2\hat{j}+10\hat{k})$ and $(10\hat{i}-2\hat{j}+5\hat{k})$ respectively. Then, the velocity of their centre of mass is

(a) $5\hat{i}+2\hat{j}-8\hat{k}$ (b) $7\hat{i}+2\hat{j}-8\hat{k}$
(c) $7\hat{i}-2\hat{j}+8\hat{k}$ (d) $5\hat{i}-2\hat{j}+8\hat{k}$

EAMCET-2007

Ans. (c) : Given, $m_1=6$ kg, $m_2=4$kg

$$\vec{V_1}=5\hat{i}-2\hat{j}+10\hat{k}$$

$$\vec{V_2}=10\hat{i}-2\hat{j}+5\hat{k}$$

∴ Velocity of centre of mass

$$\vec{V}_{CM}=\frac{m_1\vec{V_1}+m_2\vec{V_2}}{m_1+m_2}$$

$$=\frac{6\left(5\hat{i}-2\hat{j}+10\hat{k}\right)+4\left(10\hat{i}-2\hat{j}+5\hat{k}\right)}{6+4}$$

$$=\frac{30\hat{i}-12\hat{j}+60\hat{k}+40\hat{i}-8\hat{j}+20\hat{k}}{10}$$

$$=\frac{70\hat{i}-20\hat{j}+80\hat{k}}{10}$$

$$\boxed{\vec{v}_{CM}=7\hat{i}-2\hat{j}+8\hat{k}}$$

86. A system of two particles is having masses m_1 and m_2. If the particle of mass m_1 is pushed towards the center of mass of particles through a distance d, by what distance the particle of mass m_2 should be moved so as to keep the centre of mass of particles at the original position?

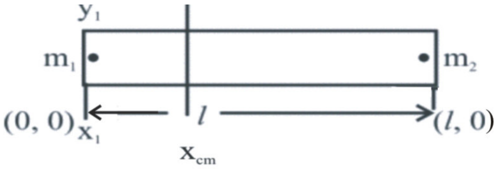
(a) $\frac{m_1}{m_1+m_2}d$ (b) d

(c) $\frac{m_1}{m_2}d$ (d) $\frac{m_2}{m_1}d$

TS EAMCET (Engg.)-2016
AIPMT - 2004

Ans. (c) : Center of mass system

$$x_{cm}=\frac{m_1x_1+m_2x_2}{m_1+m_2}$$



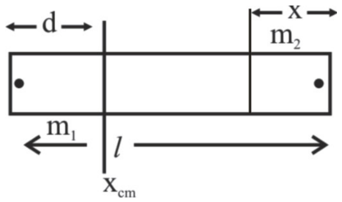
at initially centre of mass of system

$$x_{cm_1}=\frac{m_1\times 0+m_2\times l}{m_1+m_2}$$

$$x_{cm_1}=\frac{m_2}{m_1+m_2}\times l$$

After shifting the mass m_1 toward centre of mass by distance d and m_2 by distance x

@apna_pdf



$$x_{cm_2} = \frac{m_1 \times d + m_2(l - x)}{m_1 + m_2}$$

$$= \frac{m_1 \times d + m_2(l - x)}{m_1 + m_2}$$

$$x_{cm_2} = \frac{m_1 d + m_2 l - m_2 x}{m_1 + m_2}$$

According to question

$$x_{cm_1} = x_{cm_2}$$

$$\frac{m_2}{m_1 + m_2} \times l = \frac{m_1 d + m_2 l - m_2 x}{m_1 + m_2}$$

$$m_2 l = m_1 d + m_2 l - m_2 x$$

$$x = \frac{m_1}{m_2} d$$

87. A loaded spring gun of mass M fires a bullet of mass m with a velocity v at an angle of elevation θ. The gun is initially at rest on a horizontal frictionless surface. After firing, the center of mass of the gun-bullet system

(a) moves with a velocity $\frac{v(M - m)}{M + m}$ in the horizontal direction

(b) moves with velocity $\frac{mv\cos\theta}{(M + m)}$

(c) moves with a velocity $v\left(\frac{m}{M + m}\right)$

(d) moves with velocity $\left(\frac{mv\sin\theta}{M + m}\right)$

TS EAMCET(Medical)-2015

Ans. (d) : Initially, The Gun and bullet both are at rest. Since there is no applied external force in the horizontal direction, the CM of the gun and bullet will not have any acceleration.

From the principle of conservationof momentum, the CM will not move in the horizontal direction.

After firing,

Centre of mass along x-direction, we get

$v(x) = v\cos\theta\ (x) = 0$

Centre of mass along y-direction

$$v_y = \left(\frac{mv\sin\theta}{m + M}\right)$$

88. A small disc of radius 2 cm is cut from a disc of radius 6 cm. If the distance between their centers is 3.2 cm, what is the shift in the centre of mass of the disc?

(a) 0.4 cm (b) 2.4 cm

(c) 1.8 cm (d) 1.2 cm

JIPMER-2008

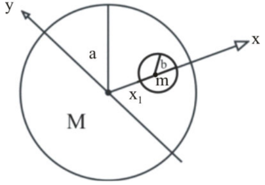
Ans. (a) :

Given,

Radius of complete disc (a) = 6 cm

Radius of small disc (b) = 2 cm

Distance (x_1) = 3.2 cm



$$\vec{r}_{cm} = \frac{M(0,0) + (-m)(x_1, 0)}{M + (-m)}$$

$$\vec{x}_{cm} = \frac{M \times (0) + (-m) \times (x_1)}{M - m}, \quad \vec{y}_{cm} = \frac{M \times 0 + (-m) \times (0)}{M - m}$$

$$\vec{x}_{cm} = \frac{-mx_1}{M - m}, \quad \vec{y}_{cm} = 0$$

So, position of new centre of mass is

$$\vec{x}_{cm} = \frac{-mx_1}{M - m} \qquad ....(i)$$

Let, surface charge density of disc is σ So, surface charge density $= \frac{\text{mass}}{\text{per unit area}}$

$$\sigma = \frac{M}{\pi a^2}$$

$$M = \sigma \pi a^2$$

Similarly, $\sigma = \frac{m}{\pi b^2}$ (a & b are radius respectively)

$$m = \sigma \pi b^2$$

Putting value of M and m in equation (i), we get

$$\vec{x}_{cm} = \frac{-\sigma\pi b^2 x_1}{\sigma\pi a^2 - \sigma\pi b^2}$$

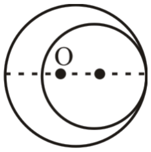
$$\vec{x}_{cm} = \frac{-b^2 x_1}{a^2 - b^2}$$

$$= \frac{-(2)^2 \times 3.2}{(6)^2 - (2)^2} = -\frac{12.8}{36 - 4} = \frac{-12.8}{32}$$

$$\vec{x}_{cm} = -0.4\,\text{cm}$$

So, the shift in centre of mass of disc is 0.4 cm in negative x - direction.

89. A circular plate of uniform thickness has a diameter of 56 cm. A circular portion of diameter 42 cm is removed from one edge of the plate as shown in the figure below. The position of centre of mass of the remaining portion is



(a) 7 cm to the left of the centre of plate

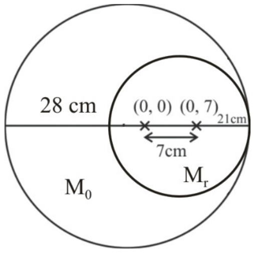
(b) 8 cm to the left of the centre of plate

@apna_pdf

(c) 9 cm to the left of the centre of plate
(d) 10 cm to the left of the centre of plate

Assam CEE-2016

Ans. (c) :



Let, M_0 = mass of circular plate.

$M_0 = \rho\pi r^2 = \rho\pi(28)^2$

M_r = removed mass of circular plate

$M_r = \rho\pi(r)^2 = \rho\pi(21)^2$

mass of remaining portion = $M_0 - M_r$

$= \rho\pi(28)^2 - \rho\pi(21)^2$

$$x_{cm} = \frac{\left[\rho\pi(28)^2\times 0\right]-\left[\rho\pi(21)^2\times 7\right]}{\rho\pi\left[(28)^2-(21)^2\right]}$$

$$x_{cm} = \frac{-(21)^2\times 7}{(28)^2-(21)^2}$$

$$x_{cm} = \frac{-3087}{784-441}$$

$$x_{cm} = -9\text{cm}$$

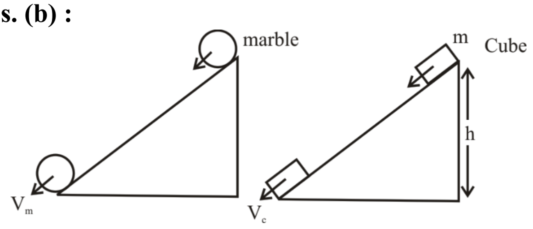
negative sign denote 9cm left to the centre of plate.

90. A marble and a cube of equal mass are initially at rest. Now the marble rolls and cube slides down a frictionless ramp. When they arrive at the bottom, the ratio of speed of the cube with respect to the centre of mass and speed of the marble is

(a) 7 : 5
(b) $\sqrt{7}:\sqrt{5}$
(c) 5 : 3
(d) $\sqrt{5}:\sqrt{3}$

Assam CEE-2014

Ans. (b) :



For cube-

$$(KE)_A + (PE)_A = (KE)_B + (PE)_B$$

$$0 + mgh = \frac{1}{2}mV_c^2 + 0$$

$$mgh = \frac{1}{2}mV_c^2$$

$$V_c = \sqrt{2gh} \quad ....(i)$$

For marble-

$$(KE)_A + (PE)_A = (KE)_B + (PE)_B$$

$$0 + mgh = \frac{1}{2}mV_m^2 + \frac{1}{2}I\omega^2 + 0$$

$$mgh = \frac{1}{2}mV_m^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{V_m}{r}\right)^2 + 0 \qquad [\because v = r\omega]$$

$$mgh = \frac{1}{2}mV_m^2 + \frac{2}{10}mV_m^2$$

$$gh = \frac{1}{2}V_m^2 + \frac{1}{5}V_m^2$$

$$gh = \frac{7V_m^2}{10}$$

$$V_m^2 = \frac{10}{7}gh$$

$$V_m = \sqrt{\frac{10}{7}gh} \quad ....(ii)$$

Dividing equation (i) and (ii), we get -

$$\frac{V_c}{V_m} = \sqrt{\frac{2gh}{\frac{10}{7}gh}}$$

$$\frac{V_c}{V_m} = \sqrt{\frac{7}{5}}$$

$$V_c : V_m = \sqrt{7} : \sqrt{5}$$

91. A body of mass m_1 = 4 kg moves at $5\hat{i}$ m/s and another body of mass m_2 = 2 kg moves at $10\hat{i}$ m/s. The kinetic energy of centre of mass is

(a) $\frac{200}{3}$J
(b) $\frac{500}{3}$J
(c) $\frac{400}{3}$J
(d) $\frac{800}{3}$J

AP EAMCET -2010

Ans. (c) : Given that,

$m_1 = 4\text{kg}, \ m_2 = 2\text{kg}$

$$\frac{dr_1}{dt} = 5\hat{i}\ m/s, \ \frac{dr_2}{dt} = 10\hat{i}\ m/s$$

Velocity of centre of mass =

$$v_{cm} = \frac{m_1\frac{dr_1}{dt} + m_2\frac{dr_2}{dt}}{m_1 + m_2} = \frac{(4\times 5)i + (2\times 10)i}{4+2}$$

$$v_{cm} = \frac{40}{6}\hat{i} = \frac{20}{3}\hat{i}$$

The kinetic energy of the centre of the mass of system-

$$K.E_{cm} = \frac{1}{2}mv_{cm}^2$$

$$= \frac{1}{2}(4+2)\times\frac{20}{3}\times\frac{20}{3}$$

$$\boxed{K.E_{cm} = \frac{400}{3}J}$$

@apna_pdf

92. Choose correct statement

A. The position of centre of mass of a system is dependent on the choice of coordinate system.
B. Newton's second law of motion is applicable to the centre of mass of the system.
C. Internal forces cannot change the state of centre of mass.
D. Internal forces can change the state of centre of mass

(a) Both A and B are correct
(b) Both B and C are wrong
(c) Both A and C are wrong
(d) Both A and D are wrong

AP EAMCET -2012

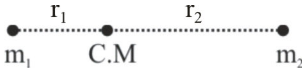
Ans. (d) : We know that,
At the centre of mass depends on the mass distribution of the system and external force acting on it hence statement A & D both are wrong.

93. Two particles of masses m_1 and m_2 ($m_1 > m_2$), initially at rest, move towards each other under an inverse square law force of attraction. Pick out the correct statement about the centre of mass (CM) of the system

(a) The CM moves towards m_1.
(b) The CM moves towards m_2.
(c) The CM remains at rest.
(d) The motion of CM is accelerated.

AMU-2008

Ans. (c) : The correct option is the CM remains at rest



Now,

$$\frac{r_1}{r_2} = \frac{m_2}{m_1}$$

At the m_1 is near the centre of mass. As the two masses are attracted, m_2 is more accelerated then m_1 and at energy instant to the centre of mass remains at the same place, because the system is isolated.

94. Two masses of 6 and 2 units are at positions $(6\hat{i} - 7\hat{j})$ and $(2\hat{i} + 5\hat{j} - 8\hat{k})$ respectively. The co-ordinates of the centre-of-mass (c.m.) are

(a) (2, –5, 3)
(b) (5, –5, –3)
(c) (5, –4, –2)
(d) (5, –4, –4)

AMU-2014

Ans. (c) : Given,

$m_1 = 6$ unit
$m_2 = 2$ unit

$$\vec{r}_1 = (6\hat{i} - 7\hat{j})$$

$$\vec{r}_2 = (2\hat{i} + 5\hat{j} - 8\hat{k})$$

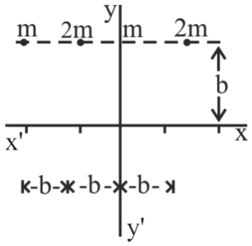
Co-ordinate of the centre of mass $(\vec{x}_{cm}) = \dfrac{m_1\vec{r}_1 + m_1\vec{r}_2}{m_1 + m_2}$

$$\vec{x}_{cm} = \frac{6(6\hat{i} - 7\hat{j}) + 2\times(2\hat{i} + 5\hat{j} - 8\hat{k})}{6+2}$$

$$= \frac{36\hat{i} - 42\hat{j} + 4\hat{i} + 10\hat{j} - 16\hat{k}}{8}$$

$$\vec{x}_{cm} = 5\hat{i} - 4\hat{j} - 2\hat{k}$$

95. With O as the origin of the coordinate axis, the X and Y – coordinates of the centre of mass of the system of particles shown in the figure may be given as

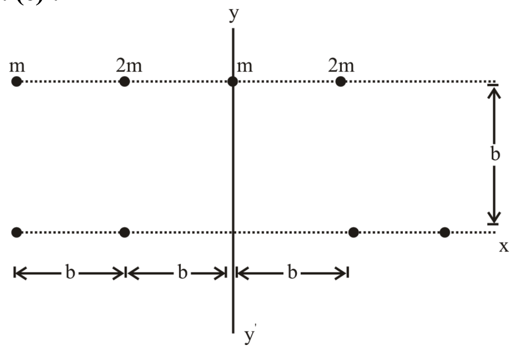


(a) $\left(-\frac{b}{2}, 0\right)$
(b) $\left(-\frac{b}{2}, b\right)$
(c) $\left(-\frac{b}{3}, b\right)$
(d) $\left(-\frac{2}{5}b, b\right)$

Here m and 2 m represent the masses of the particles.

AMU-2006

Ans. (c) :



The taking moments with respect to 0 $\vec{x}_{cm}$ is

$$\vec{x}_{cm} = \frac{m(-2b) + 2m(-b) + m\times 0 + 2m(b)}{m + 2m + m + 2m}$$

$$= -\frac{b}{3}$$

$$\vec{y}_{cm} = b$$

such that at the $\vec{R}_{cm} = \left(\frac{-b}{3}, b\right)$

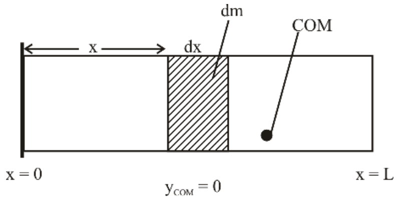
96. A straight rod of length L has one of its ends at the origin and the other at x = L. If the mass per unit length of the rod is given by Ax where A is a constant, where is its mass centre

(a) L/3
(b) L/2
(c) 2L/3
(d) 3L/4

AMU-2005

@apna_pdf

Ans. (c) : At let to be assume A is a constant



x_c = coordinate of center of mass

At given data,

$$\frac{M}{L} = Ax$$

$$X_{COM} = \frac{\int x.dm}{\int dm}$$

$$= \frac{\int_0^L x.Axdx}{\left\{\int_0^L Axdx\right\}} \quad \left(\text{Total Mass} = \int_0^L Axdx\ \right)$$

$$\frac{dm}{dx} = A.x$$

$$dm = Ax.dx$$

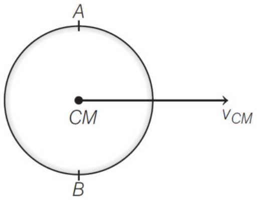
$$X_{COM} = \frac{\int_0^L x^2 dx}{\int_0^L x.dx}$$

$$X_{COM} = \frac{\left[\frac{x^3}{3}\right]_0^L}{\left[\frac{x^2}{2}\right]_0^L}$$

$$X_{COM} = \frac{\frac{L^3}{3}}{\frac{L^2}{2}}$$

$$X_{COM} = \frac{2L}{3}$$

97. A wheel of bicycle is rolling without slipping on a level road. The velocity of the centre of mass is v_{CM} , then true statement is



(a) The velocity of point A is 2 v_{CM} and velocity of point B is zero

(b) The velocity of point A is zero and velocity of point B is 2 v_{CM}

(c) The velocity of point A is 2 v_{CM} and velocity of point B is $- v_{CM}$

(d) The velocities of both A and B are v_{CM}

AIPMT-2001

Ans. (a) : Let the circle radius is R and with ω.

The velocity of centre of mass of body rolling without slipping is given by.

$v_{cm} = R\omega$

velocity at point A –

$v_A = v_{cm} + R\omega$

$= v_{cm} + v_{cm}$

$v_A = 2v_{cm}$

velocity at point B –

$v_B = v_{cm} - R\omega = v_{cm} - v_{cm}$

$v_B = 0$

98. A light rod of length l has two masses m_1 and m_2 attached to its two ends. The moment of inertia of the system about an axis perpendicular to the rod and passing through the centre of mass is

(a) $\frac{m_1 m_2}{m_1 + m_2} l^2$

(b) $\frac{m_1 + m_2}{m_1 m_2} l^2$

(c) $(m_1 + m_2)l^2$

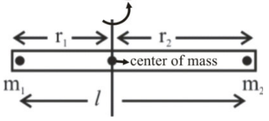
(d) $\sqrt{m_1 m_2} l^2$

NEET- 2016

Ans. (a) : To the given data,

Length of rod = l

masses = $(m_1 + m_2)$



From the above figure

$$r_1 = \frac{m_1 \times 0 + m_2 \times l}{m_1 + m_2}$$

$$= \frac{m_2 l}{m_1 + m_2}$$

$$r_2 = \frac{m_1 \times l + m_2 \times 0}{m_1 + m_2}$$

$$= \frac{m_1 l}{m_1 + m_2}$$

Now at the moment of inertia about centre of mass

$$I = m_1 r_1^2 + m_2^2 r_2^2$$

$$= m_1 \times \frac{m_2^2 l^2}{(m_1 + m_2)^2} + m_2 \times \frac{m_1^2 l^2}{(m_1 + m_2)^2}$$

$$= \frac{m_1 m_2 l^2}{(m_1 + m_2)^2}(m_1 + m_2)$$

$$\boxed{I = \frac{m_1 m_2 l^2}{m_1 + m_2}}$$

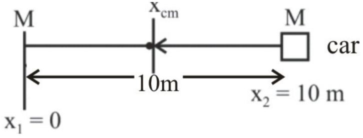
99. A car of mass M is tied to one end of a massless rope of length 10 m. The other end of the rope is in the hands of a man of mass M. The entire system is on a smooth horizontal surface. The man is at x = 0 and the cart at x = 10m. If the man pulls the cart by the rope, the man and the cart will meet at the point

@apna_pdf

(a) they will never meet (b) x = 10 m
(c) x = 5 m (d) x = 0

AIPMT- 1997

Ans. (c) : Since, there is no external force applied in on the system so the centre of mass will always be at rest.



$$x_{COM} = \frac{M_{man} \times 0 + M_{car} \times 10}{M_{man} + M_{car}}$$

$$x_{COM} = \frac{0 + 10m}{2m}$$

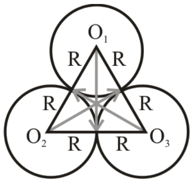
$$x_{COM} = 5$$

100. Three identical metal balls each of radius r are placed touching each other on a horizontal surface such that an equilateral triangle is formed with centers of three balls joined. The centre of mass of the system is located at

(a) horizontal surface
(b) centre of one of the balls
(c) line joining the centers of any two balls
(d) point of intersection of the medians

AIPMT-1999

Ans. (d) : To the given data,
Three identical metal balls each of radius r touching each other so the equilateral triangle therefore, centre of mass of the system at the which is the (point of intersection of the medians) of the triangle.

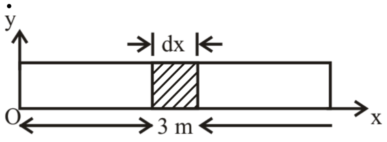


101. A rod is of length 3 m and its mass acting per unit length is directly proportional to distance x from its one end. The centre of gravity of the rod from that end will be at

(a) 1.5 m (b) 2 m
(c) 2.5 m (d) 3 m

AIPMT-2002

Ans. (b) :



Assuming consider an elementary length dx
Mass of small element of dx length is, dm = kx.dx
[where k is the proportionality constant]
At the centre of gravity of the rod (x_d) is given.

$$x_d = \frac{\int_0^3 x.dm}{\int_0^3 dm}$$

$$(x_d) = \frac{\int_0^3 kx.dx.x}{\int_0^3 kx.dx} = \frac{\int_0^3 x^2.dx}{\int_0^3 x.dx} = \frac{\left[\frac{x^3}{3}\right]_0^3}{\left[\frac{x^2}{2}\right]_0^3}$$

Or $$(x_d) = \frac{27/3}{9/2} = 2\text{ m}$$

102. A solid sphere of radius R is placed on a smooth horizontal surface. A horizontal force F is applied at height h from the lowest point. For the maximum acceleration of the centre of mass

(a) h = R
(b) h = 2 R
(c) h = 0
(d) the acceleration will be same and there is no relation between h and R

AIPMT-2002

Ans. (d) : According to question surface is smooth so rolling motion is not possible. sphere will perform linear motion.
Hence,
The acceleration of the centre of the mass is -
$a = \frac{F}{m}$, where F is applied force.
Hence, the acceleration will be same and there is no relation between h and R

103. Two bodies of masses 1 kg and 3 kg have position vectors $\hat{i} + 2\hat{j} + \hat{k}$ and $-3\hat{i} - 2\hat{j} + \hat{k}$, respectively. The centre of mass of this system has a position vector

(a) $-2\hat{i} + 2\hat{k}$ (b) $-2\hat{i} - \hat{j} + \hat{k}$
(c) $2\hat{i} - \hat{j} - 2\hat{k}$ (d) $-\hat{i} + \hat{j} + \hat{k}$

AIPMT-2009

Ans. (b) : Given that,
Masses of bodies –
$M_1 = 1$ kg & $M_2 = 3$kg
Position vectors are –

$$\vec{r}_1 = \hat{i} + 2\hat{j} + \hat{k}$$
$$\vec{r}_2 = -3\hat{i} - 2\hat{j} + \hat{k}$$

Position vector of the centre of mass

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$$= \frac{1 \times (\hat{i} + 2\hat{j} + \hat{k}) + 3(-3\hat{i} - 2\hat{j} + \hat{k})}{1 + 3}$$

$$= \frac{\hat{i} + 2\hat{j} + \hat{k} + (-9\hat{i} - 6\hat{j} + 3\hat{k})}{4}$$

$$= \frac{-8\hat{i} - 4\hat{j} + 4\hat{k}}{4} = \frac{4(-2\hat{i} - \hat{j} + \hat{k})}{4}$$

$$\boxed{\vec{r}_{cm} = -2\hat{i} - \hat{j} + \hat{k}}$$

@apna_pdf

104. Two persons of masses 55 kg and 65 kg respectively, are at the opposite ends of a boat. The length of the boat is 3 m and weights 100 kg. The 55 kg man walks up to the 65 kg man and sits with him. If the boat is in still water the centre of mass of the system shifts by

(a) 3 m
(b) 2.3 m
(c) zero
(d) 0.75 m

AIPMT-2012

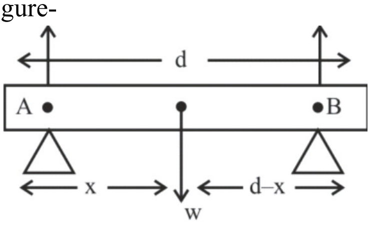
Ans. (c) : According to the question, boat and persons make a system and centre of mass of the system is internally at rest. And there is no external force acting on it. Then, the centre of mass of the system will remain at rest. Here there is no shifting in the centre of mass of the system.

105. A rod of weight w is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distanced d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on A is

(a) $\frac{wx}{d}$
(b) $\frac{wd}{x}$
(c) $\frac{w(x-d)}{x}$
(d) $\frac{w(d-x)}{d}$

AIPMT-2015

Ans. (d) : According to question, situation is shown in below figure-



Where,

N_A = Normal reaction on A
N_B = Normal reaction on B
w = weight of rod

In equilibrium position,

$N_A + N_B = w$ ....(i)

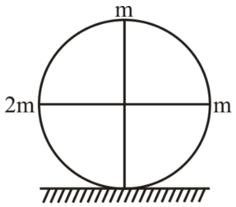
By Torque balancing about centre of mass of the rod,

$N_A x = N_B(d-x)$ ....(ii)

Putting the value of N_B from equation (i)

$$N_A x = (w - N_A)(d - x)$$
$$N_A x = wd - wx - N_A d + N_A x$$
$$N_A = \frac{w(d-x)}{d}$$

106. Three particles are attached to a ring of mass m and radius R as shown in the figure. The centre of mass the ring has a speed V_0 and rolls without slipping on a horizontal surface. The kinetic energy of the system in the position shown in the figure is



(a) $6\text{ m }V_0^2$
(b) $12\text{ m }V_0^2$
(c) $2\text{ m }V_0^2$
(d) $8\text{m }V_0^2$

AP EAMCET(Medical)-2016

Ans. (a) : When body is pure rolling

$V_0 = R\omega$

Speed on the left side is:

$$V_1 = \sqrt{V_0^2 + (R\omega)^2}$$
$$V_1 = \sqrt{V_0^2 + V_0^2} \qquad (\because\ V_0 = R\omega)$$
$$V_1 = V_0\sqrt{2}$$

Kinetic energy $(E_1) = \frac{1}{2} \times 2m \times V_1^2$

$$= m \times V_0^2 \times 2 = 2\,m V_0^2$$

Speed on the top-

$$V_2 = V_0 + R\omega$$
$$V_2 = V_0 + V_0 = 2V_0$$
$$E_2 = \frac{1}{2} m V_2^2$$
$$E_2 = \frac{1}{2} m (2V_0)^2$$
$$E_2 = 2m\,V_0^2$$

Speed on right side-

$$V_3 = \sqrt{V_0^2 + (R\omega)^2}$$
$$V_3 = \sqrt{V_0^2 + (V_0)^2}$$
$$V_3 = \sqrt{2}V_0$$
$$E_3 = \frac{1}{2} m (V_3)^2 = \frac{1}{2} m \times (\sqrt{2}V_0)^2$$
$$E_3 = m\,V_0^2$$

Kinetic energy of ring

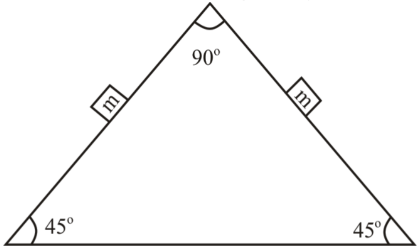
$$E_{ring} = \frac{1}{2} m V_0^2 + \frac{1}{2} I\omega^2$$
$$= \frac{1}{2} m V_0^2 + \frac{1}{2} m R^2 \omega^2$$
$$= \frac{1}{2} m V_0^2 + \frac{1}{2} m (R\omega)^2$$
$$= \frac{1}{2} m V_0^2 + \frac{1}{2} m V_0^2 \qquad (V_0 = R\omega)$$
$$E_{ring} = m\,V_0^2$$

Total kinetic energy (E) = $E_1 + E_2 + E_3 + E_{ring}$

$$= 2mV_0^2 + 2mV_0^2 + mV_0^2 + mV_0^2$$
$$= 6\,mV_0^2$$

@apna_pdf

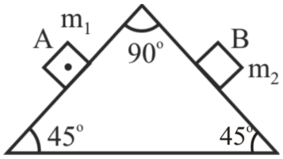
107. Two blocks of equals mass are released on two smooth sides of a double inclined plane with a fixed base as shown in the figure. If each angle of inclination is 45^o, the acceleration of the centre of mass of the system of the two blocks is (Acceleration due to gravity = 10 ms^{-2})



(a) 10 ms^{-2} vertically downward
(b) 10 ms^{-2} vertically upward
(c) 5 ms^{-2} vertically downward
(d) 5 ms^{-2} vertically upward

AP EAMCET(Medical)-2016

Ans. (a) : Given that,
Mass of two blocks are equal
$m_1 = m_2 = m$



Acceleration of A = a_1
& acceleration of B = a_2, both are equal.
Gravity due to acceleration (g) = -10 m/s^2
Acceleration of centre of mass of system

$$a_{cm} = \frac{m_1a_1 + m_2a_2}{m_1 + m_2}$$

$$\Rightarrow \frac{m\times(-10) + m\times(-10)}{m+m}$$

$$\boxed{a_{cm} = \frac{-20m}{2m} \Rightarrow -10\,m/s^2}$$

108.

List A	List B
(i) Position of centre mass	**(v) is zero**
(ii) The algebraic sum of moments of all the masses about CM	**(vi) is non-uniform gravitational field**
(iii) CM and centre of gravity coincide	**(vii) is in dependent of frame of reference**
(iv) CM and centre of gravity do not coincide	**(viii) in uniform gravitational field**

The correct match is
(a) (i)-(v), (ii)-(vii), (iii)-(vi), (iv)-(viii)
(b) (i)-(vii), (ii)-(v), (iii)-(vi), (iv)-(viii)
(c) (i)-(vii), (ii)-(v), (iii)-(viii), (iv)-(vi)
(d) (i)-(viii), (ii)-(v), (iii)-(vi), (iv)-(vii)

AP EMCET(Medical)-2011

Ans. (c) :

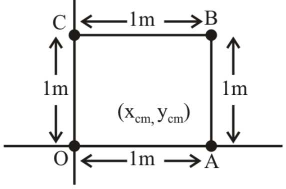
List-A	List-B
(i) Position of centre mass	is in dependent of frame of reference
(ii) The algebraic sum of moments of all the masses about CM	is zero
(iii) CM and centre of gravity coincide	in uniform gravitational field
(iv) CM and centre of gravity do not coincide	is non-uniform gravitational field

109. Four particles, each of mass 1 kg are placed at the corners of a square OABC of side 1 m. 'O' is at the origin the co–ordinate system. OA and OC are aligned along positive X-axis and positive Y-axis respectively. The position vector of the centre of mass is (in 'm'):

(a) $\hat{i}+\hat{j}$
(b) $\frac{1}{2}(\hat{i}+\hat{j})$
(c) $(\hat{i}-\hat{j})$
(d) $\frac{1}{2}(\hat{i}-\hat{j})$

AP EAMCET(Medical)-2006

Ans. (b) : From the question given that, Four particles, each of mass 1 kg
So, $m_1 = m_2 = m_3 = m_4 = 1$ kg
and OA = AB = OC = BC = 1m
According to the question –



Co-ordinate of O = (x_1, y_1) = (0, 0)

Co-ordinate of A = (x_2, y_2) = (1, 0)

Co-ordinate of B = (x_3, y_3) = (1, 1)

Co-ordinate of C = (x_4, y_4) = (0, 1)

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3 + m_4x_4}{m_1 + m_2 + m_3 + m_4}$$

$$x_{cm} = \frac{1\times0 + 1\times1 + 1\times1 + 1\times0}{1+1+1+1} = \frac{2}{4} = \frac{1}{2}m$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3 + m_4y_4}{m_1 + m_2 + m_3 + m_4}$$

$$= \frac{1\times0 + 1\times0 + 1\times1 + 1\times1}{1+1+1+1} = \frac{2}{4} = \frac{1}{2}m$$

The position vector of centre of mass $(\vec{r}_{cm})$

$$= x_{cm}\hat{i} + y_{cm}\hat{j}$$

$$\Rightarrow \frac{1}{2}\hat{i} + \frac{1}{2}\hat{j} \Rightarrow \frac{1}{2}(\hat{i}+\hat{j})$$

@apna_pdf

110. Three particles each of mass 1 kg are placed at the corners of a right angled triangle *A*OB. O Being the origin of the coordinate system (OA and OB) along positive X-direction and positive Y-direction). If OA = OB = 1 m, the positive vector of the centre of mass (in meters) is:

(a) $\frac{\hat{i}+\hat{j}}{3}$ (b) $\frac{\hat{i}-\hat{j}}{3}$

(c) $\frac{2(\hat{i}+\hat{j})}{3}$ (d) $(\hat{i}-\hat{j})$

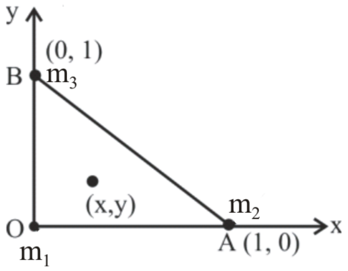
AP EAMCET(Medical)-2005

Ans. (a) : Given that,

$m_1 = m_2 = m_3 = 1\text{kg}$

OA = OB = 1 m

According to question-



Co-ordinate of O = $(x_1, y_1) = (0, 0)$

Co-ordinate of A = $(x_2, y_2) = (1, 0)$

Co-ordinate of B = $(x_3, y_3) = (0, 1)$

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$= \frac{1\times0 + 1\times1 + 1\times0}{1+1+1} = \frac{1}{3}\text{m}$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3}$$

$$= \frac{1\times0 + 1\times0 + 1\times1}{1+1+1} = \frac{1}{3}\text{m}$$

The position vector of centre of mass

$$\vec{r}_{cm} = x_{cm}\hat{i} + y_{cm}\hat{j}$$

$$\vec{r}_{cm} = \frac{1}{3}\hat{i} + \frac{1}{3}\hat{j}$$

$$\boxed{\vec{r}_{cm} = \frac{1}{3}(\hat{i}+\hat{j})}$$

111. Four particles, each of mass 1kg, are placed at the corners of a square of side 1m in the X-Y plane. If the point of intersection of the diagonals of the square, is taken as the origin, the co-ordinates of the centre of mass are:

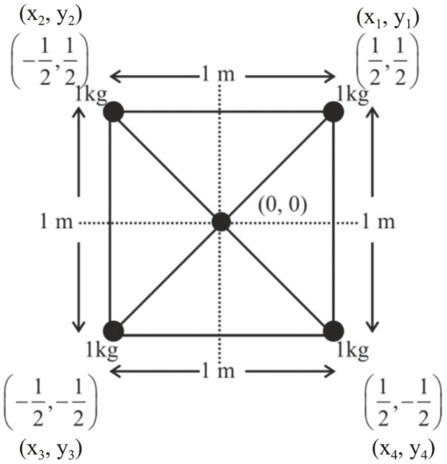
(a) (1, 1) (b) (-1, 1)

(c) (1, -1) (d) (0, 0)

AP EAMCET(Medical)-2004

Ans. (d) : Given, $m_1 = m_2 = m_3 = m_4 = 1$ kg

Coordinate of intersection of diagonal of square is origin.


(x_2, y_2)
$\left(-\frac{1}{2}, \frac{1}{2}\right)$
(x_1, y_1)
$\left(\frac{1}{2}, \frac{1}{2}\right)$
1 m
1kg
1kg
(0, 0)
1 m
1 m
1kg
1kg
1 m
$\left(-\frac{1}{2}, -\frac{1}{2}\right)$
(x_3, y_3)
$\left(\frac{1}{2}, -\frac{1}{2}\right)$
(x_4, y_4)

$$x_{cm} = \frac{(m_1x_1) + (m_2x_2) + (m_3x_3) + (m_4x_4)}{(m_1 + m_2 + m_3 + m_4)}$$

$$x_{cm} = \frac{\left[1\times\frac{1}{2}\right] + \left[1\times\left(-\frac{1}{2}\right)\right] + \left[1\times\left(-\frac{1}{2}\right)\right] + \left[1\times\left(\frac{1}{2}\right)\right]}{(1+1+1+1)}$$

$$x_{cm} = 0$$

$$y_{cm} = \frac{(m_1y_1) + (m_2y_2) + (m_3y_3) + (m_4y_4)}{(m_1 + m_2 + m_3 + m_4)}$$

$$y_{cm} = \frac{\left[1\times\frac{1}{2}\right] + \left[1\times\frac{1}{2}\right] + \left[1\times\left(-\frac{1}{2}\right)\right] + \left[1\times\left(-\frac{1}{2}\right)\right]}{(1+1+1+1)}$$

$$y_{cm} = 0$$

So, coordinate of center of mass

$(x_{cm}, y_{cm}) = (0,0)$

112. One end of a thin uniform rod of length L and mass M_1 is riveted to the centre of a uniform circular disc of radius r and mass M_2, so that both are coplanar. The centre of mass of the combination from the centre of the disc is:

(a) $\frac{L(M_1 + M_2)}{2M_1}$

(b) $\frac{LM_1}{2(M_1 + M_2)}$

(c) $\frac{2(M_1 + M_2)}{LM_1}$

(d) $\frac{2LM_1}{(M_1 + M_2)}$

AP EAMCET(Medical)-2003

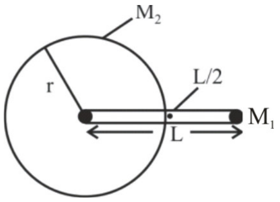
@apna_pdf

Ans. (b) : Given that,

Length of uniform rod is L and mass of the rod is M_1

Radius of circular disc is r and mass is M_2

According to the question –



The center of the mass of the combination from the centre of the disc is

$$r_{cm} = \frac{\left(M_1 \times \frac{L}{2}\right) + (M_2 \times 0)}{(M_1 + M_2)}$$

$$r_{cm} = \frac{M_1 L}{2(M_1 + M_2)}$$

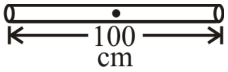
113. A uniform rod of length one meter is bent at its midpoint to make 90° angle. The distance of the centre of mass from the centre of rod is:

(a) 36.1 cm (b) 25.2 cm

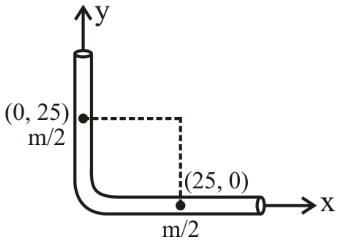
(c) 17.7 cm (d) zero

AP EAMCET(Medical)-2001

Ans. (c) : According to the question



Bend at mid point-



Here,

$$m_1 = \frac{m}{2}$$

$(x_1, y_1) = (25, 0)$

And,

$$m_2 = \frac{m}{2}$$

$(x_2, y_2) = (0, 25)$

$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

$$x_{cm} = \frac{\left(\frac{m}{2} \times 25\right) + \left(\frac{m}{2} \times 0\right)}{\left(\frac{m}{2} + \frac{m}{2}\right)}$$

$$x_{cm} = \frac{25}{2}$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2}{m_1 + m_2}$$

$$y_{cm} = \frac{\left(\frac{m}{2} \times 0\right) + \left(\frac{m}{2} \times 25\right)}{\left(\frac{m}{2} + \frac{m}{2}\right)}$$

$$y_{cm} = \frac{25}{2}$$

Distance of the centre of mass from the centre of rod,

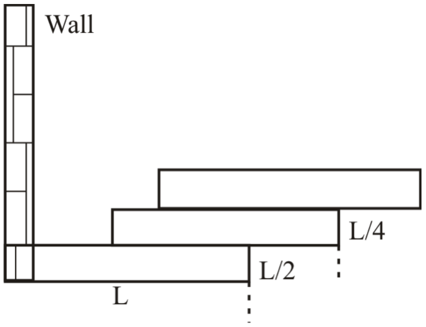
$$r_{cm} = \sqrt{x_{cm}^2 + y_{cm}^2}$$

$$r_{cm} = \sqrt{\left(\frac{25}{2}\right)^2 + \left(\frac{25}{2}\right)^2}$$

$$r_{cm} = \frac{25\sqrt{2}}{2} = \frac{25}{\sqrt{2}}$$

$r_{cm} = 17.7$ cm

114. Three bricks each of length L and mass M are arranged as shown from the wall figure. The distance of the centre of mass of the system from the wall is



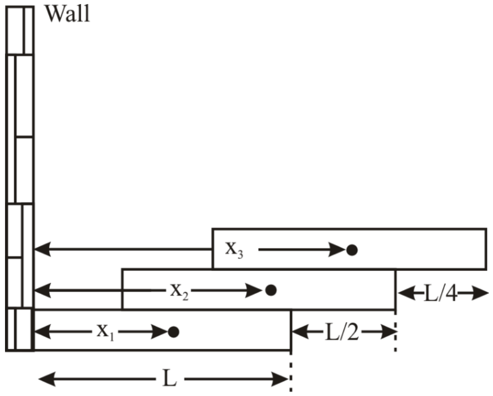
(a) L/4 (b) L/2

(c) (3/2)L (d) (11/12)L

(e) (5/6)L

Kerala CEE - 2010

Ans. (d)



@apna_pdf

Distance from wall $(x_1) = \frac{L}{2}$

Distance from wall $(x_2) = \frac{L}{2} + \frac{L}{2} = L$

Distance from wall $(x_3) = \frac{L}{2} + \frac{L}{2} + \frac{L}{4} = \frac{5}{4}L$

Now,

$$X_{cm} = \frac{M_1x_1 + M_2x_2 + M_3x_3}{M_1 + M_2 + M_3}$$

$$X_{cm} = \frac{M \times \frac{L}{2} + M \times L + M \times \frac{5L}{4}}{3M}$$

$$X_{cm} = \frac{\frac{11}{4}ML}{3M}$$

$$X_{cm} = \frac{11}{12}L$$

115. Two bodies of mass 4 kg and 5 kg are moving along east and north directions with velocities 5 m/s and 3 m/s respectively. Magnitude of the velocity of centre of mass of the system is

(a) $\frac{25}{9}\text{m/s}$

(b) $\frac{9}{25}\text{m/s}$

(c) $\frac{41}{9}\text{m/s}$

(d) $\frac{16}{9}\text{m/s}$

AP EAMCET -2013

Ans. (a) : Given,

$m_1 = 4$ kg

$m_2 = 5$ kg

$v_1 = 5\ \hat{i}$ m/s (x direction)

$v_2 = 3\ \hat{j}$ m/s (y direction)

$$v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

$$v_{cm} = \frac{4 \times 5\hat{i} + 5 \times 3\hat{j}}{9}$$

$$v_{cm} = \frac{20}{9}\hat{i} + \frac{15}{9}\hat{j}$$

$$v_{cm} = \sqrt{\left(\frac{20}{9}\right)^2 + \left(\frac{15}{9}\right)^2}$$

$$v_{cm} = \sqrt{\frac{400 + 225}{81}}$$

$$v_{cm} = \frac{25}{9}\text{m/s}$$

116. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the circumferences of the discs touch. The centre of mass of the new disc is at a distance αR from the centre of the bigger disc. The value of α is

(a) $\frac{1}{2}$

(b) $\frac{1}{3}$

(c) $\frac{1}{4}$

(d) $\frac{1}{6}$

AP EAMCET -2011

Ans. (b) : We know that,

$$\sigma = \frac{\text{mass}}{\text{area}}$$

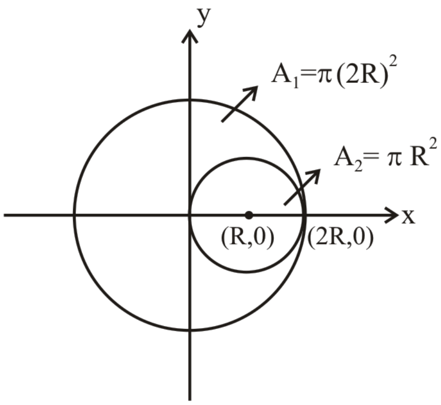
Mass of the bigger disc-

$M_1 = \sigma \times \pi \times (2R)^2$

$M_1 = 4\pi R^2\sigma$

Mass of the smaller disc-

$M_2 = \sigma \times \pi R^2$



Centre of the mass of cutting disc,

$$X_{cm} = \frac{M_1x_1 + M_2x_2}{M_1 + M_2}$$

$$X_{cm} = \frac{\left[4\pi R^2\sigma \times 0\right] + \left[\left(-\sigma \times \pi R^2\right) \times R\right]}{\left[4\pi R^2\sigma + \left(-\sigma\pi R^2\right)\right]} = -\frac{R}{3}$$

$$\alpha R = -\frac{R}{3} \qquad (\because x_{cm} = \alpha R)$$

$$|\alpha| = \left|-\frac{1}{3}\right|$$

$$\alpha = \frac{1}{3}$$

@apna_pdf

(b) Angular Displacement Velocity and Acceleration (Eq. of Rotational Motion)

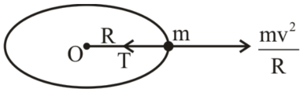
117. A stone of mass 1 Kg is tied to end of a mass less string of length 1 m. If the breaking tension of the string is 400 N, then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is

(a) 40 ms^{-1} (b) 20 ms^{-1}

(c) 400 ms^{-1} (d) 10 ms^{-1}

JEE Main-31.01.2023, Shift-II

Ans. (b) : Given,
Mass (m) = 1 kg
Breaking tension (T) = 400 N, R = 1 m



We know that,

$$T = \frac{mv^2}{R}$$

$$400 = \frac{1\times v^2}{1}$$

$$v = 20\,m/s$$

118. A body is moving with constant speed, in a circle of radius 10m. The body completes one revolution in 4s. At the end of 3rd second, the displacement of body (in m) from its starting point is:

(a) 15π (b) $10\sqrt{2}$

(c) 30 (d) 5π

JEE Main-31.01.2023, Shift-II

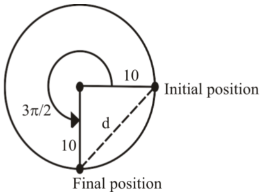
Ans. (b) : Given,
Radius of circle = 10 m
Body's completing 2π angle in 4 second

$$\text{Angular velocity}(\omega) = \frac{2\pi}{4}$$

$$\omega = \frac{\pi}{2}\text{ rad/sec.}$$

Angular displacement = ωt
Angular displacement in 3 sec.

$$= 0\left(\frac{\pi}{2}\right)(3) = \frac{3\pi}{2}\text{rad.}$$



Hence, displacement (d) = $\sqrt{10^2+10^2}$

$d = 10\sqrt{2}$ m

119. A thin circular ring of mass M and radius R rotates about an axis through its centre and perpendicular to its plane, with a constant angular velocity ω. Four small spheres each of mass m (negligible radius) are kept gently to the opposite ends of two mutually perpendicular diameters of the ring. The new angular velocity of the ring will be

(a) 4ω (b) $\frac{M}{4m}\omega$

(c) $\left(\frac{M+4m}{M}\right)\omega$ (d) $\left(\frac{M}{M-4m}\right)\omega$

(e) $\left(\frac{M}{M+4m}\right)\omega$

JEE Main - 26/06/2022 (Shift-I)
APEAMCET- 11/07/2022 (Shift-I)
Kerala CEE - 2008

Ans. (e) : As the mass are putted gently, so no external torque is applied on the system

$\therefore$ $L = I\omega$ = constant

Now,

$L_1 = MR^2\omega$ and $L_2 = (I_1 + I_2)\omega'$ $\begin{bmatrix} I_1 = MR^2 \\ I_2 = 4mR^2 \end{bmatrix}$

$$L_2 = (MR^2 + 4mR^2)\omega'$$

Since, angular momentum is conserved,

$L_1 = L_2$

$MR^2\omega = (M+4m)R^2\,\omega'$

$\omega' = \left(\frac{M}{M+4m}\right)\omega$

120. The angular speed of a fly-wheel making 180 rpm is ______

(a) (4π) rad.s^{-1} (b) (6π) rad.s^{-1}

(c) (2π) rad.s^{-1} (d) $\left(\frac{54}{\pi}\right)$ rad.s^{-1}

CG PET - 22/05/2022
AP EAMCET-03.09.2021, Shift-I

Ans. (b) : Given, N = 180 rpm
As we know that the relationship between angular velocity and rpm is -

$$\omega = \frac{2\pi\times N}{60}$$

$$\omega = \frac{2\pi\times 180}{60} = 6\pi\text{ rad.s}^{-1}$$

121. A uniform rod of length 60 cm is placed with one end in contact with the horizontal table and is then inclined at an angle 30° to the horizontal and allowed to fall. The angular velocity of the rod when it becomes horizontal is–
(acceleration due to gravity = 10 ms^{-2})

(a) 9 rad s^{-1} (b) 6 rad s^{-1}

(c) 5 rad s^{-1} (d) 8 rad s^{-1}

AP EAMCET-07.07.2022, Shift-II

@apna_pdf

Ans. (c) : Given,

Length, L = 60 cm = 0.6 metre,

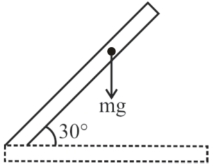
Angle, $\theta = 30^o$

P.E. of rod = $mg.\ \frac{L}{2}\ \sin 30°$

P.E. of rod = $mg\frac{L}{2}\times\frac{1}{2}$

Rotational K.E, $\frac{I\omega^2}{2} = \frac{1}{2}\ \frac{mL^2}{3}\omega^2$

Apply law of conservation of energy,



$(\text{Potential energy})_{\text{initial}} = (\text{K.E})_{\text{final}}$

$$\Rightarrow \quad \frac{mgL}{2}\times\frac{1}{2} = \frac{1}{2}\times\frac{1}{3}mL^2\,\omega^2$$

$$\omega^2 = \frac{3g}{2L}$$

$$\omega = \sqrt{\frac{3g}{2L}} = \sqrt{\frac{3\times10}{2\times0.6}}$$

$$\omega = \sqrt{25}$$

$$\omega = 5\,\text{rad/sec}$$

122. A fan is rotating with an angular speed 300 rpm. The fan is switched off, and it takes 80 s to come to rest. Assuming constant angular deceleration, the number of revolutions made by the fan before it comes to rest is

(a) 400 (b) 200

(c) 300 (d) 314

AP EAMCET-06.07.2022, Shift-I

Ans. (b) : Given,

Angular speed = 300 rpm

or, $\omega_0 = \frac{300}{60} = 5\text{rps}$

Angular speed of fan at t = 80 sec

$\omega = 0$ (comes to rest)

Now, according to the question,

$$\omega = \omega_0 + \alpha t$$

$$0 = 5 + (\alpha\times 80)$$

$$-5 = (\alpha\times 80)$$

$$\alpha = \frac{-5}{80}\ \text{rad/s}^2$$

So, the number of revolution made by the fan before is cones to rest,

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$0 = (5)^2 + 2\times\left(\frac{-5}{80}\right)\theta$$

$$0 = 25 - \frac{\theta}{8}$$

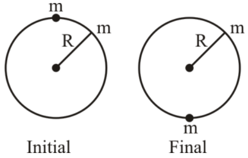
$$\therefore \quad \theta = 200\ \text{rev}$$

123. A disc of mass 1 kg and radius R is free of rotate about a horizontal axis passing through its centre and perpendicular to the plane of disc. A body of same mass as that of disc is fixed at the highest point of the disc. Now the system is released, when the body comes to the lowest position, its angular speed will be $4\sqrt{\frac{x}{3R}}$ rads^{-1} where x = ______

JEE Main-26.07.2022, Shift-I

Ans. (5) : Given,

Angular speed, $\omega = 4\sqrt{\frac{x}{3R}}$ ....(i)



Initial Final

By conservation of mechanical energy,

$$2mgR = \frac{1}{2}I_{\text{disc}}\omega^2 + \frac{1}{2}I_{\text{particle}}\omega^2$$

$$2mgR = \frac{\omega^2}{2}\left[\frac{mR^2}{2} + mR^2\right] \quad (\because\ I_{\text{particle}} = mR^2)$$

$$2mgR = \frac{\omega^2}{2}\cdot\frac{3}{2}mR^2$$

$$\frac{3}{4}\omega^2 = \frac{2g}{R}$$

$$\omega^2 = \frac{8g}{3R}$$

$$\omega = \sqrt{\frac{8g}{3R}} \quad ....(ii)$$

According to the equation (i) and (ii),

$$4\sqrt{\frac{x}{3R}} = \sqrt{\frac{8g}{3R}}$$

$$\frac{16x}{3R} = \frac{8g}{3R}$$

$$2x = g$$

$$x = \frac{g}{2} \quad (g = 10\ \text{m/s}^2)$$

$$x = \frac{10}{2}$$

$$x = 5$$

124. Which of the following quantities are quantized in quantum mechanics?

(a) Energy (b) Angular Momentum

(c) Both (a) and (b) (d) Neither (a) nor (b)

Assam CEE-31.07.2022

Ans. (c) : In quantum mechanics, total energy and angular momentum is quantized of rotating electron in circular orbit.

The concept of quantization is broad and it is put forth that physical quantities can assume only certain discrete values. Light energy, angular momentum, electrical charges and matter can be quantized on the microscopic level.

@apna_pdf

125. A merry-go-round rotating at a constant angular speed completes 9 rotations in 18 seconds. What is it angular speed?

(a) $\pi/2$ rad/s (b) π rad/s
(c) 2π rad/s (d) 3π rad/s

TS EAMCET 19.07.2022, Shift-I

Ans. (b) : Given that,

$\theta = 9$ rev. $= 9\times2\pi$ rad.

$t = 18$ second

We know that –

Angular speed, $\omega = \dfrac{\theta}{t}$

$$\omega = \frac{9\times2\pi}{18}\ ,\quad \omega = \pi \text{ rad/s}$$

126. A wheel moving with initial angular velocity 20 rad/s, stops after 50 revolutions. The time taken by the wheel to stop is

(a) 17.1 sec (b) 15.7 sec
(c) 31.4 sec (d) 47.1 sec

TS EAMCET 30.07.2022, Shift-II

Ans. (c) : Given,

$\omega_0 = 20$ rad/s, $\omega_f = 0$, $\theta = 50$ rev

We know that,

1 rev $= 2\pi$ rad.

$\therefore$ $\theta = 50$ rev $= 50 \times 2\pi$ rad

$\theta = 50 \times 6.283$ rad

$\theta = 314.15$ rad

Now,

$$\theta = \frac{(\omega_0 - \omega_f)}{2}\times t$$

$$t = \frac{2\theta}{\omega_0 - \omega_f}$$

$$t = \frac{2\times314.15}{20-0}$$

$t = 31.45$ sec

127. The angular speed of a motor wheel is increased from 1200 rpm to 3120 rpm in 16 seconds. The angular acceleration of the motor wheel is

(a) 6π rad/s^2 (b) 8π rad/s^2
(c) 2π rad/s^2 (d) 4π rad/s^2

Karnataka CET-2022

Ans. (d) : Given,

$N_1 = 1200$ rpm

$N_2 = 3120$ rpm

$t = 16$ sec

Initial angular speed-

$$\omega_i = \frac{2\pi N_1}{60} = \frac{2\pi\times1200}{60} = 40\pi \text{ rad/s}$$

Final angular speed-

$$\omega_f = \frac{2\pi N_2}{60} = \frac{2\pi\times3120}{60} = 104\pi \text{ rad/s}$$

So, Angular acceleration-

$$\alpha = \frac{(\omega_f - \omega_i)}{t} = \frac{(104-40)\pi}{16} = 4\pi \text{ rad/s}^2$$

128. The angular speed of a fly wheel moving with uniform angular acceleration changes from 1200 rpm to 3120 rpm in 16 seconds. The angular acceleration in rad/s^2 is

(a) 12π (b) 104π
(c) 2π (d) 4π

NEET-17.07.2022

Ans. (d) : Given,

Angular acceleration changes from 1200 rpm to 3120 rpm in 16 sec.

Angular acceleration

$$\alpha = \frac{\omega_f - \omega_i}{t} \qquad [\text{From equation } \omega_f = \omega_i + \alpha t]$$

$$\omega_f = 3120\times\frac{2\pi}{60} \text{ rad/sec}$$

$\omega_f = 104\pi$ rad/sec

$$\omega_i = 1200\times\frac{2\pi}{60} \text{ rad/sec}$$

$\omega_i = 40\pi$ rad/sec

Then,

$$\alpha = \frac{104\pi - 40\pi}{16} = \frac{64\pi}{16}$$

$\alpha = 4\pi$ rad/sec^2

129. The angular velocity of a ceiling fan reduces to 50% after 36 rotations since it is switched off. Assuming uniform retardation, the number of rotations it further makes before coming to rest is______.

(a) 12 (b) 18
(c) 48 (d) 36

AP EAMCET-06.09.2021, Shift-II

Ans. (a) : From the third law of motion, the equation of circular motion is given below

$$\omega^2 = \omega_o^2 - 2\alpha\theta$$

Angular velocity reduces (50%), $\omega = \dfrac{\omega_0}{2}$

So, $$\left(\frac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha(2\pi n) \qquad \left(\begin{array}{l}\because\ \theta = 2\pi n\\ \ \ n = 36\end{array}\right)$$

$$\alpha = \frac{3\omega_0^2}{4\times4\pi\times36} \qquad ....(i)$$

Now let Fan completes total n revolution

From the starting to come to rest.

$$0 = \omega_0^2 - 2\alpha\,(2\pi n) \Rightarrow n = \left(\frac{\omega_0^2}{4\alpha\pi}\right)$$

Substituting the value of α from equation (i), we get-

$$n = \frac{\omega_0^2}{4\pi}\times\frac{4\times4\pi\times36}{3\omega_0^2} = 48 \text{ revolution}$$

Number of rotation $= 48 - 36 \Rightarrow 12$

130. A body initially at rest, starts rotating with a uniform acceleration and covers 100π rad in the first 5 seconds. Its angular speed at the end of 5 seconds is _____

@apna_pdf

(a) 20π rad.s^{-1} (b) 30π rad.s^{-1}
(c) 40π rad.s^{-1} (d) 10π rad.s^{-1}

AP EAMCET-03.09.2021, Shift-II

Ans. (c) : Given, $\omega_i = 0$ [start from rest]

$\theta = 100\pi$ rad

$t = 5$ sec

From using the second equation of angular of motion,

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$100\pi = 0 + \frac{1}{2}\times\alpha\times 25$$

$$\alpha = \frac{200\pi}{25}$$

$$\alpha = 8\pi \text{ rad/sec}^2$$

Now, to find angular speed, we use –

$$\omega = \omega_0 + \alpha t$$

$$\omega = 0 + 8\pi\times 5$$

$$\omega = 40\pi \text{ rad/sec}$$

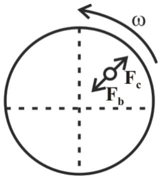
131. When a coin is kept at a distance of 4 cm from the centre of a circular table rotating at an angular velocity of ω, what will be the minimum distance from the centre where the coin will start slipping?

(a) 2 cm (b) 3 cm
(c) 1 cm (d) 8 cm

Tripura-2021

Ans. (c) : Given,

$r_1 = 4$ cm, $r_2 = ?$



A coin placed on uniformly rotating turntable just slip if it placed at a distance of 4 cm from the centre of the angular velocity of the turntable is doubled, it will just slip at a distance of.

Since it just slip so maximum friction will be equal to the centripetal force in both the case.

We know that

$$F_s = m\omega^2 r$$

If we double the ω, then r will also self adjust to a new r, since the static friction will remain same.

We have,

$$m\omega_1^2 r_1 = m\omega_2^2 r_2$$

$$\omega_1^2 r_1 = \omega_2^2 r_2$$

$$\frac{r_1}{r_2} = \left(\frac{\omega_2}{\omega_1}\right)^2$$

$$\frac{4}{r_2} = \left(\frac{2\omega_1}{\omega_1}\right)^2$$

$\Rightarrow$ $r_2 = 1$ cm

132. A rigid solid sphere is spinning around an axis without any external torque. Due to change in temperature, its volume increase by 1%. Then its angular speed ——

(a) Increases nearly by 1%
(b) Decreases by 1%
(c) Decreases by nearly 0.67%
(d) Decreases by nearly 0.37%

AP EAMCET-06.09.2021, Shift-I

Ans. (c) :

Volume of sphere (V) $= \frac{4}{3}\pi R^3$

$$\frac{\Delta V}{V} = \frac{3\Delta R}{R}$$

Its volume increase by 1%

$$1 = \frac{3\Delta R}{R}$$

$$\frac{\Delta R}{R} = 0.33\% \quad \text{....(i)}$$

If anybody is spinning around an axis without any external torque then his angular momentum is conserved.

Angular momentum $(L) = \frac{2}{5}MR^2\omega$

Change in angular momentum $\frac{\Delta L}{L} = \frac{2\Delta R}{R} + \frac{\Delta\omega}{\omega}$

Since $\frac{\Delta L}{L} = 0$ (momentum is constant)

$$\frac{\Delta\omega}{\omega} = \frac{-2\Delta R}{R}$$

From equation (i)

$$\frac{\Delta\omega}{\omega} = -2\times 0.33$$

$$\frac{\Delta\omega}{\omega} = -0.66$$

Therefore, ω decrease by 0.67%

133. A wheel is rotating at 480 rpm. Find the magnitude of angular acceleration required to stop the wheel in 8 seconds?

(a) 2π rad. s^{-2} (b) 2.5π rad. s^{-2}
(c) 2 rad. s^{-2} (d) 3.5π rad. s^{-2}

AP EAMCET-25.08.2021, Shift-II

Ans. (a) : Given that, Time (t) = 8 sec

N = 480 rpm (revolution per minute)

$N = \frac{480}{60}$ rps (revolution per second)

N = 8 rps.

Angular acceleration $(\alpha) = \frac{d\omega}{dt}$

$$\alpha = \frac{(2\pi N)}{dt} \quad (\omega = 2\pi N)$$

$$\alpha = \frac{2\pi\times 8}{8}$$

$$\alpha = 2\pi \text{ rad/sec}^2$$

@apna_pdf

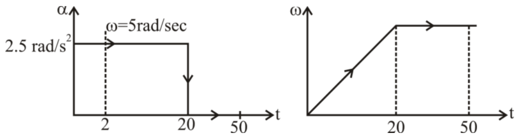
134. A wheel undergoes a constant angular acceleration from time t = 0 to t = 20s and thereafter angular acceleration is zero. If angular velocity at t = 2 s is found to be 5 rad/s, then the number of revolutions made by the wheel in time interval t = 0 s to t = 50 s is:

(a) $1000/\pi$ (b) $600\,\pi$
(c) $1500/\pi$ (d) $2000/\pi$

TS EAMCET 05.08.2021, Shift-II

Ans. (a) : The interval consists of two stages. The first interval $0 \le t \le 20$ s, consists of constant angular acceleration, then it is given as,

$$\alpha = \frac{5}{2}\text{rad/sec}^2$$



$\omega = \alpha t$

$$\alpha_{\text{at 2sec}} = \frac{\omega}{t} = \frac{5}{2}\text{rad/sec}^2$$

But it is given that angular acceleration is constant upto 20sec

$$\therefore \quad \alpha = \frac{d\omega}{dt}$$

$$\int d\omega = \int \alpha dt$$

$\omega = \alpha t$ [Linear variation w.r.t. time]

Now after 20sec angular acceleration is zero [$20 < \omega \le 50$]

$$\alpha = \frac{d\omega}{dt}$$

$d\omega = 0$

ω = Constant

$$\omega = \frac{\Delta\theta}{\Delta t}$$

Then, analyzing the first stage, we find

$$\theta_1 = \frac{1}{2}\alpha t^2$$

$$\theta_1 = \frac{1}{2}\times\frac{5}{2}\times(20)^2 \quad \left(\because\ t = 20\text{sec}, \alpha = \frac{5}{2}\right)$$

$\theta_1 = 500$ rad.

$\omega = \alpha t$

$$\omega = \frac{5}{2}\times 20 \quad (\because\ t = 20\text{sec.})$$

$\omega = 50$ rad/sec.

Analyzing the second stage, we obtain,

$\theta_2 = \theta_1 + \omega\Delta t$

$\theta_2 = 500 + 50 \times (50 - 20)$

$= 500 + 50 \times 30 = 500 + 1500$

$\theta_2 = 2000$ rad

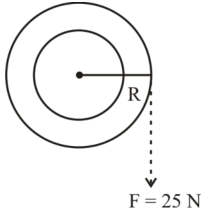
$$\text{The number of revolutions} = \frac{2000}{2\pi} = \frac{1000}{\pi}$$

135. A rope is wound around a solid cylinder of mass 1kg and radius 0.4 m. What is the angular acceleration of cylinder, if the rope is pulled with a force of 25N ?
(cylinder is rotating about its own axis)

(a) 125 rad/s^2 (b) 50 rad/s^2
(c) 10 rad/s^2 (d) 1 rad/s^2

MHT-CET 2020

Ans. (a) : Given, mass of solid cylinder (M) = 1kg
radius of cylinder (R) = 0.4m
force (F) = 25N
Angular acceleration (α) = ?



Moment of inertia of solid cylinder –

$$I = \frac{MR^2}{2} \qquad \text{....(i)}$$

We know that,

$\because$ Torque $(\tau) = FR$ .....(ii)

and $\tau = I\alpha$ ......(iii)

Equating equation (ii) and (iii), we get

$$\alpha = \frac{FR}{I}$$

Putting the value of I from equation (i), we get –

$$\text{Angular acceleration } (\alpha) = \frac{F.R}{\left(\frac{MR^2}{2}\right)}$$

$$\alpha = \frac{2.F.R}{MR^2} = \frac{2F}{MR}$$

$$\alpha = \frac{2\times 25}{1\times 0.4} = \frac{2\times 25\times 10}{4}$$

$\alpha = 125$ rad/s^2

136. A disc of radius 0.4 m and mass 1 kg rotates about an axis passing through its centre and perpendicular to its plane. The angular acceleration is 10 rad/s^2. The tangential force applied to the rim of the disc is

(a) 2 N (b) 4 N
(c) 3 N (d) 1 N

MHT-CET 2020

Ans. (a) : Given :
radius (r) = 0.4 m, Mass (m) = 1kg
Angular acceleration (α) = 10 rad/s^2
Tangential force (F) = ?

$$\text{Moment of inertia of disc } I = \frac{mr^2}{2}$$

$$I = \frac{1\times(0.4)^2}{2}$$

$I = 0.08\,\text{kg m}^2$

@apna_pdf

$\because$ Torque, $\tau = I\alpha$

$\tau = 0.08 \times 10$

$\tau = 0.8 \text{N m}$

$\tau = Fr$

$F = \frac{\tau}{r} = \frac{0.8}{0.4}$

$F = 2 \text{ N}$

137. A disc rolls down a smooth inclined plane without slipping. An inclined plane make an angle of 60° with the vertical. The linear acceleration of the disc along the inclined plane is

(g = acceleration due to gravity, $\sin 30^\circ = \cos 60^\circ = \frac{1}{2}$, $\sin 60^\circ = \cos 30^\circ = \frac{\sqrt{3}}{2}$)

(a) $\frac{g}{9}$ (b) $\frac{g}{6}$

(c) $\frac{g}{3}$ (d) $\frac{g}{18}$

MHT-CET 2020

Ans. (c) : The acceleration of rolling disc is:

$$a = \frac{g\sin\theta}{1+\left(\frac{k^2}{R^2}\right)}$$

Where θ =angle made by the inclined plane with the horizontal

$\because \theta = 30^\circ$ and for a disc, $\frac{k^2}{R^2} = \frac{1}{2}$

$$\therefore\ a = \frac{g\sin 30^\circ}{1+\frac{1}{2}} = \frac{g \times \frac{1}{2}}{\frac{3}{2}}$$

$$a = \frac{g}{3}$$

138. A horizontal circular platform of mass 100 kg is rotating at 5 r.p.m. about vertical axis passing through its centre. A child of mass 20 kg is standing on the edge of platform. If the child comes to the centre of platform then frequency of rotation will become

(a) 7 r.p.m. (b) 9 r.p.m.

(c) 5 r.p.m. (d) 12 r.p.m.

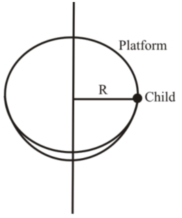
MHT-CET 2020

Ans. (a) : Given,

Mass of circular platform = 100 kg

Speed of platform $(\omega)_i = 5$ rpm

Mass of child = 20 kg



Initial moment of Inertia (I_i)

$$= \frac{1}{2}100.R^2 + 20R^2 = 70R^2$$

The child goes to center of platform then final moment of inertia,

$$I_f = \frac{1}{2} \times 100R^2 = 50\ R^2$$

By law of conservation of angular momentum,

$L_i = L_f$

$I_i\ \omega_i = I_f\ \omega_f$

$70\ R^2 \times 5 = 50R^2 \times \omega_f$

$\omega_f = 7$ r.p.m.

139. The power 'P' is supplied to rotating body having moment of inertia 'I' and angular acceleration 'α'. Its instantaneous angular velocity is

(a) $\frac{I}{P\alpha}$ (b) $\frac{P}{I\alpha}$

(c) $PI\alpha$ (d) $\frac{\alpha}{PI}$

MHT-CET 2020

Ans. (b) : As we know,

Power (P) = F.v

$P = F.(r.\ \omega)$ ....(i)

and

Torque $(\tau) = F.\ r$ .....(ii)

From equation (i) and (ii), we get

$P = \tau.\ \omega$

Now, $\tau = I.\alpha$

So, $P = I\alpha.\omega$

$$\omega = \frac{P}{I\alpha}$$

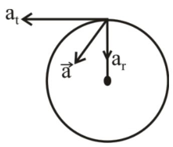
140. In non uniform circular motion, the ratio of tangential to radial acceleration is (r = radius of circle, v = speed of the particle, α = angular acceleration)

(a) $\frac{\alpha^2 r^2}{v}$ (b) $\frac{\alpha^2 r}{v^2}$

(c) $\frac{\alpha r^2}{v^2}$ (d) $\frac{v^2}{r^2\alpha}$

MHT-CET 2018, 2020

Ans. (c) :



Tangential acceleration $(a_t) = r\ \alpha$ ....(i)

and radial acceleration $(a_r) = \frac{v^2}{r}$ ....(ii)

Dividing equation (i) by (ii), we get–

$$\frac{a_t}{a_r} = \frac{r\alpha}{\frac{v^2}{r}} = \frac{\alpha r^2}{v^2}$$

@apna_pdf

141. A solid body rotates with angular velocity $\omega = at\hat{i} + bt^2\hat{j}$ where a = 1 rad/s^2 and b = 0.5 rad/s^2 and t is in seconds. Calculate the angle between the vectors of the angular velocity and the angular acceleration at t = 1 sec.

(a) $\cos^{-1}\left(\frac{5}{\sqrt{10}}\right)$ (b) $\cos^{-1}\left(\frac{4}{\sqrt{10}}\right)$

(c) $\cos^{-1}\left(\frac{2}{\sqrt{10}}\right)$ (d) $\cos^{-1}\left(\frac{3}{\sqrt{10}}\right)$

TS EAMCET 28.09.2020, Shift-I

Ans. (d) : Given that,

Angular Velocity $(\omega) = at\hat{i} + bt^2\hat{j}$

a = 1 rad/s^2, b = 0.5 rad/s^2

$$|\omega| = \sqrt{(at)^2 + (bt^2)^2}$$

$$= \sqrt{(1\times1)^2 + (0.5\times1^2)^2} = \sqrt{1+\left(\frac{1}{2}\right)^2} = \sqrt{\frac{5}{4}}$$

$$|\omega| = \frac{\sqrt{5}}{2}$$

$$\beta = \frac{d\omega}{dt} = \left(a\hat{i} + 2bt\hat{j}\right)$$

$$|\beta| = \sqrt{(a)^2 + (2bt)} = \sqrt{1+(2\times.5\times1)^2} = \sqrt{2}$$

$$\therefore \cos\alpha = \frac{\omega\beta}{|\omega|.|\beta|}$$

$$= \frac{(at\hat{i} + bt^2\hat{j})(a\hat{i} + 2bt\hat{j})}{\frac{\sqrt{5}}{2}.\sqrt{2}}$$

$$\Rightarrow \alpha = \cos^{-1}\left(\frac{a^2t + 2b^2t^3}{\sqrt{\frac{5}{2}}}\right)$$

$$\alpha = \cos^{-1}\left(\frac{1^2\times1 + 2(0.5)^2\times1^3}{\sqrt{\frac{5}{2}}}\right)$$

$$\alpha = \cos^{-1}\left(\frac{3}{\sqrt{10}}\right)$$

142. A disc has mass 'M' and radius 'R'. How much tangential force should be applied to the rim of the disc so as to rotate with angular velocity 'ω' in time 't'?

(a) $\frac{MR\omega}{4t}$ (b) $\frac{MR\omega}{2t}$

(c) $\frac{MR\omega}{t}$ (d) $MR\omega t$

MHT-CET-2020, 2018

Ans. (b) : Given,

Mass of disc = M

And radius of disc = R

We know that, $\tau = I\alpha$

But $\tau = F \times R$

$\because$ Moment of inertia of disc $I = \frac{1}{2}MR^2$

And angular acceleration, $\alpha = \frac{\omega}{t}$

$$\therefore \quad F \times R = \frac{1}{2}MR^2 \times \frac{\omega}{t}$$

$$\text{Force, } F = \frac{MR\omega}{2t}$$

143. A uniform circular disc of mass 'M' and radius 'R' is rotating in a horizontal plane about an axis passing through its centre of mass and perpendicular to its plane with an angular velocity ω. Another disc of same radius but mass (M/2) is placed gently on the first disc. The angular velocity of the system now is

(a) $\frac{3}{2}\omega$ (b) $\frac{2}{3}\omega$

(c) $\frac{1}{3}\omega$ (d) ω

UPSEE 2020

Ans. (b) : Given,

Mass of disc 1st $(m_1) = M$

Mass of disc 2nd $(m_2) = \frac{M}{2}$

Radius of both disc = R

Angular velocity of disc 1st $(\omega_1) = \omega$

We know that,

For disc 1st,

Angular momentum $(L_1) = I_1\omega_1$

Where I = moment of Inertia = $\frac{1}{2}m_1R^2$

$$L_1 = \frac{1}{2}M \times R^2 \times \omega \qquad \left[\begin{matrix}\because m_1 = M \\ \omega_1 = \omega\end{matrix}\right]$$

$$L_1 = \frac{MR^2\omega}{2}$$

For combination of disc 1st and 2nd,

Angular momentum $(L_2) = (I_1 + I_2)\omega_2$

Where I_2 = moment of Inertia = $\frac{1}{2}m_2R^2$

$$L_2 = \left(\frac{1}{2}MR^2 + \frac{1}{2}\times\frac{M}{2}\times R^2\right)\omega_2$$

$$L_2 = \left(\frac{2MR^2 + MR^2}{4}\right)\omega_2$$

$$L_2 = \frac{3}{4}MR^2\omega_2$$

@apna_pdf

From law of conservation of momentum,

$$L_1 = L_2$$

$$\frac{MR^2\omega}{2} = \frac{3}{4}MR^2\omega_2$$

Hence,

$$\omega_2 = \frac{2}{3}\omega$$

144. The angular speed of the wheel of a vehicle is increased from 360 rpm to 1200 rpm in 14 s. Its angular acceleration is

(a) 2π rad/s^2 (b) 28π rad/s^2
(c) 120π rad/s^2 (d) 1 rad/s^2

NEET- (Oct.)2020

Ans. (a) : Given, n_1 = 360 rpm, n_2 = 1200 rpm, t = 14 sec

We know that, $\omega = 2\pi n$

$$\because \quad \omega_i = 2\pi \times \frac{360}{60} = 12\pi \text{ rad/sec}$$

And $$\omega_f = 2\pi \times \frac{1200}{60} = 40\pi \text{ rad/sec}$$

Since, $$\omega_f = \omega_i + \alpha t$$

$$40\pi = 12\pi + \alpha \times 14$$

$$\alpha = \frac{28\pi}{14} = 2\pi \text{ rad/sec}$$

145. A coin placed on a rotating turn table just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turntable is doubled, it will just slip at a distance of ……….

(a) 1 cm (b) 2 cm
(c) 4 cm (d) 8 cm

AP EAMCET-25.09.2020, Shift-I

Ans. (a) : Given, $\omega_2 = 2\omega_1,\ r_1 = 4\text{cm}$

A body placed on a non-inertial frame of reference which is rotating about its axis, experiences a centrifugal force.

$\because \quad F = Mr\omega^2$

According to the question,

$$F_1 = F_2$$

$$Mr_1\omega_1^2 = Mr_2\omega_2^2$$

$$4 \times \omega_1^2 = r_2(2\omega_1)^2$$

$$4 \times \omega_1^2 = 4\omega_1^2 r_2$$

$$r_2 = \frac{4}{4}$$

$$r_2 = 1\text{cm}$$

146. A disc spinning at the rate 27.5 rad s^{-1} is slowed at the rate 10 rad s^{-2}. The time after which it will come to rest is

(a) 2.75 s (b) 5.5 s
(c) 1.25 s (d) 3.5 s
(e) 6.2 s

Kerala CEE 2020

Ans. (a) : Given, initial angular velocity (ω_i) = 27.5 rad/sec, angular acceleration (α) = –10 rad/sec^2,

final angular velocity $(\omega_f) = 0$

According to kinematics law of rotational motion-

$$\omega_f = \omega_i + \alpha t$$

$$\alpha t = \omega_f - \omega_i$$

$$t = \frac{\omega_f - \omega_i}{\alpha}$$

$$t = \frac{0 - 27.5}{-10} \Rightarrow t = \frac{27.5}{10}$$

$$t = 2.75 \text{ sec}$$

147. Assume proton is rotating along a circular path of radius 1m under a centrifugal force of 4×10^{-12} N. If the mass of proton is 1.6×10^{-27} kg, then its angular velocity of rotation is

(a) 5×10^7 rad/s (b) 10^{15} rad/s
(c) 2.5×10^7 rad/s (d) 5×10^{14} rad/s

TS-EAMCET-14.09.2020, Shift-1

Ans. (a) : Given,

Radius of proton (r) = 1 m

Mass of proton, $m = 1.6\times10^{-27}$ kg

$$F_{\text{centrifugal}} = 4\times10^{-12} \text{ N}$$

We know that,

$$\because \quad F_{\text{centrifugal}} = m\omega^2 r$$

$$\therefore \quad \text{Angular velocity } \omega^2 = \frac{F_c}{mr}$$

$$\therefore \quad \omega = \sqrt{\frac{F_c}{mr}}$$

$$\omega = \sqrt{\frac{4\times10^{-12}}{1.6\times10^{-27}\times1}}$$

$$\omega = \sqrt{2.5\times10^{15}}$$

$$\omega = \sqrt{25\times10^{14}}$$

$$\omega = 5\times10^7 \text{ rad/s}$$

148. A wheel starting from rest gains an angular velocity of 10 rad/s after uniformly accelerated for 5s. The total angle through which it has turned is :

(a) 25 rad (b) 100 rad
(c) 25 π rad (d) 50 π rad and a vertical axis

Karnataka CET-2020

Ans. (a) : Given that, ω_i = rad/sec, ω_f = 10 rad/sec, t = 5sec

According to kinematics law of rotational motion–

$$\omega_f = \omega_i + \alpha t$$

$$10 = 0 + \alpha \times 5$$

$$\alpha = 2$$

Now, $$\theta = \omega_i t + 1/2\alpha t^2$$

$$\theta = (0\times5) + 1/2\times2\times5^2$$

$$\theta = 25 \text{ rad.}$$

@apna_pdf

149. A body of mass 10 Kg is attached to a wire 0.3 m long. Its breaking stress is 4.8×10^7 N/m². The area of cross-section of the wire is 10^{-6} m². The maximum angular velocity with which it can be rotated in a horizontal circle is

(a) 6 rad/s (b) 5 rad/s
(c) 7 rad/s (d) 4 rad/s

MHT-CET 2020

Ans. (d) : Given, M = 10 kg, l = 0.3m, A = 10^{-6} m², $\sigma = 4.8\times10^7\,\text{N/m}^2$

We know that, centripetal force $(F_C) = \dfrac{Mv^2}{r}$ .....(i)

$\because \quad F_c = \sigma\times A$

$$F_C = 4.8\times10^7\times10^{-6} = 48\text{N}$$

Putting the value of F_C equation (i), we get –

$$48 = \frac{10\times v^2}{0.3}$$

$$v^2 = \frac{48\times0.3}{10} = \frac{144}{100}$$

$$v = \frac{12}{10} = 1.2\text{m/s}$$

$$\omega_\circ = \frac{1.2}{r} = \frac{1.2}{0.3} = 4 \text{ rad/sec}$$

150. A planet is moving in a circular orbit. It completes 2 revolutions in 360 days. What is its angular frequency?

(a) 1.5×10^{-2} rad/day (b) 2.5×10^{-2} rad/day
(c) 3.5×10^{-2} rad/day (d) 4.5×10^{-2} rad/day

TS-EAMCET-09.09.2020, Shift-1

Ans. (c) : Planet complete 2 round. It means make an angle = 4π rad

T = 360 days

Applying formula,

$$\text{Angular frequency (f)} = \frac{\text{Angle}}{\text{Time}}$$

$$= \frac{4\pi}{360}$$

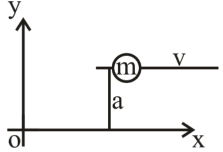
$$f = 3.5\times10^{-2}\text{ rad/day}$$

151. A wheel is rotating at 900 r.p.m. about its axis. When power is cut off it comes to rest in 1 minute. The angular retardation in rad/s² is

(a) π/2 (b) π/4
(c) π/6 (d) π/8

BITSAT-2020

Ans. (a) : Given, t = 1 min = 60 sec, N = 900 rpm



Angular velocity,

$$\omega_0 = \frac{2\pi N}{60} = \frac{2\times\pi\times900}{60}$$

$$\omega_0 = 30\pi\text{ rad/sec} \qquad ....(i)$$

Angular retardation,

$$\omega = \omega_0 - \alpha t$$

$$0 = \omega_0 - \alpha t$$

$$\alpha = \frac{\omega_0}{t}$$

Putting the value of ω_0 from (i), we get

$$\alpha = \frac{30\pi}{60}$$

$$\alpha = \frac{\pi}{2}\text{ rad/sec}^2$$

152. A flywheel starts from rest and rotates at a constant acceleration of 2rads⁻². The number of revolutions that it makes in first 10s is

(a) 16 (b) 24
(c) 32 (d) 8

AP EAMCET (17.09.2020) Shift-I

Ans. (a) : Given that,

$\omega_0 = 0$

$\alpha = 2\text{ rad/sec}^2$

t = 10 sec.

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = 0\times10 + \frac{1}{2}\times2\times10^2$$

$$\theta = 100\text{ rad}$$

2π radian is covered in 1 revolution therefore 100 radian covered in $\dfrac{100}{2\pi}$ revolution.

$$\text{Number of revolution} = \frac{100}{2\pi}$$

$$N = 16$$

153. How many revolutions does a wheel with angular speed 88rads⁻¹ make in one second?

(a) 7 (b) 14
(c) 28 (d) 44

AP EAMCET (21.09.2020) Shift-II

Ans. (b) : Given that,

ω = 88 rad/sec

We know,

$$\omega = 2\pi N$$

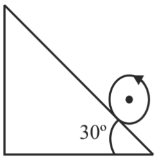
$$\therefore \quad N = \frac{\omega}{2\pi}$$

$$\text{Number of revolution per second, } N = \frac{\omega}{2\pi} = \frac{88\times7}{2\times22}$$

N = 14 rev/sec.

154. A solid sphere rolls purely on a rough inclined plane upwards with initial velocity 2.8 m/s. Find the maximum distance travelled on the inclined plane.

@apna_pdf



(a) 1.097 m (b) 5.48 m
(c) 2.083 m (d) 3.2 m

AIIMS-25.05.2019(E) Shift-2

Ans. (a) : Given, initial velocity (v) = 2.8 m/sec, angle (θ) = 30°

We know that, $a = \dfrac{g\sin\theta}{1+\left(\dfrac{k^2}{r^2}\right)}$

For a solid sphere, $I = \dfrac{2}{5}mr^2 = mk^2$

$\because \quad \dfrac{k^2}{r^2} = \dfrac{2}{5}$

Putting the value of these, we get–

$$a = \frac{10\times\sin 30^\circ}{1+\left(\frac{2}{5}\right)} \qquad (\because \; g = 10 m/s^2)$$

$$a = \frac{10\times\frac{1}{2}}{\frac{7}{5}} = \frac{5}{7/5} = 5\times\frac{5}{7} = \frac{25}{7}$$

From equation of motion,

$v^2 = u^2 - 2as$

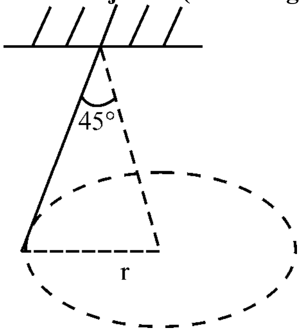
$0 = u^2 - 2as$

$(2.8)^2 = 2\times\dfrac{25}{7}\times s$

$s = \dfrac{7.84\times 7}{50}$

$s = 1.0976$ m

155. An object tied to a rope of length l = $2\sqrt{2}$ m is allowed to make rotational motion. During rotation it makes an angle θ = 45° with the vertical axis shown in figure. The tangential velocity of the object is (Assume g = 10 m/s^2)



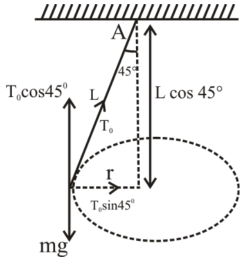
(a) $3/\sqrt{5}$ m/s (b) $\sqrt{5}$ m/s
(c) $2\sqrt{5}$ m/s (d) $1/\sqrt{5}$ m/s

TS EAMCET 09.05.2019, Shift-I

Ans. (c) : Given, Length of rope = $2\sqrt{2}$ m

Angle (θ) = 45°

g = 10 m/s^2



As we know,

$\dfrac{v^2}{rg} = \tan\theta$

Given, θ = 45°

$\dfrac{v^2}{rg} = \tan 45^\circ$

$v^2 = rg$

According to figure

$\sin 45^\circ = \dfrac{r}{L}$

$\dfrac{1}{\sqrt{2}} = \dfrac{r}{2\sqrt{2}}$

$r = 2$

$v^2 = rg$

$v^2 = 2\times 10$

$v = \sqrt{20}$

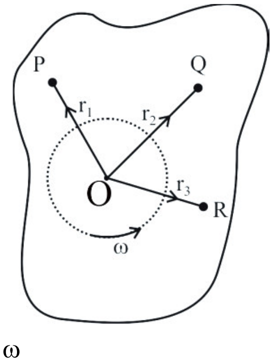
$v = 2\sqrt{5}$ m/s

156. In rotatory motion, linear velocities of all the particles of the body are

(a) Same (b) Different
(c) Zero (d) Cannot say

BITSAT-2019

Ans. (b) : Body is rotating about point O with angular velocity v.



$v_P = r_1\,\omega$

$v_Q = r_2\,\omega$

$v_R = r_3\,\omega$

So, all particles of the body will have different linear velocities.

@apna_pdf

157. A disc of radius 5 m is rotating with angular frequency 10 rad/sec. A block of mass 2 kg is to be put on the disc (friction coefficient between disc and block is μ = 0.4), then find the maximum distance from axis where the block can be placed without sliding.

(a) 2 cm (b) 3 cm
(c) 4 cm (d) 6 cm

AIIMS-26.05.2019(E) Shift-2

Ans. (c) : Given,

$r = 5m$
$\mu_k = 0.4$
$\omega = 10$ rad/sec.

We know that,

$$\mu_k g = \omega^2.x$$

$$x = \frac{\mu_k g}{\omega^2} = \frac{0.4\times10}{100} = \frac{4}{100}\,m = 4cm$$

Maximum distance x = 4 cm

158. A mass is whirled in a circular path constant angular velocity and its linear velocity is 'V'. If the string is now halved keeping the angular momentum same, the linear velocity is

(a) $\frac{V}{2}$ (b) 2V
(c) V (d) $V\sqrt{2}$

MHT-CET 2019

Ans. (b) : Given that,

Angular velocity = ω
Linear velocity = V
Length of string = Radius = R

We know,

Angular momentum, L = mvr
According to the question,
$L_1 = L_2$
$m v_1 r_1 = m v_2 r_2 \quad (\because m = \text{constant})$

Where,

$$r_1 = R \text{ and } r_2 = \frac{R}{2}$$
$$v_1 = V$$
$$V \times R = V_2 \times \frac{R}{2}$$

$\therefore \quad V_2 = 2V$

159. The angular velocity of minute hand of a clock in degree per second is

(a) 1.5 (b) 1
(c) 0.5 (d) 0.1

MHT-CET 2019

Ans. (d) : Angular velocity of minute hand of a clock

$$\omega_m = \frac{\Delta\theta}{\Delta t}$$

$$\omega_m = \frac{360^\circ}{60\times60\,sec}$$

$$\omega_m = \frac{1}{10\,sec}$$

ω_m = 0.1 degree/sec

160. Two particles A and B are moving in uniform circular motion in concentric circles of radii r_A and r_B with speed v_A and v_B respectively. Their time period of rotation is the same. The ratio of angular speed of A to that of B will be

(a) $v_A : v_B$ (b) $r_B : r_A$
(c) 1:1 (d) $r_A : r_B$

NEET (National) - 2019

Ans. (c): When time period is same then angular velocity will also same.

$$\omega = \frac{2\pi}{T}$$

$$\omega_1 = \frac{2\pi}{T_A},\ \omega_2 = \frac{2\pi}{T_B}$$

$$\frac{\omega_1}{\omega_2} = \frac{T_B}{T_A} = 1:1$$

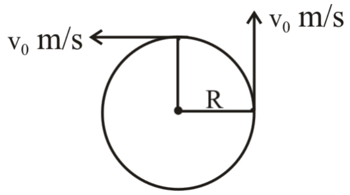
$\omega_1 : \omega_2 = 1:1$

161. A particle starting from rest, moves in a circle of radius 'r'. It attains a velocity of v_0 m/s in the n^{th} round. Its angular acceleration will be

(a) $\frac{v_0}{n}\,rad/s^2$ (b) $\frac{v_0^2}{2\pi nr^2}\,rad/s^2$
(c) $\frac{v_0^2}{4\pi nr^2}\,rad/s^2$ (d) $\frac{v_0^2}{4\pi nr}\,rad/s^2$

NEET (Odisha) - 2019

Ans. (c) : Given, radius = r, $\omega_0 = 0$, $v_f = v_0$ in n^{th} round



$$\because \quad \omega_f = \frac{v_0}{r}$$

We know that, $\omega_f^2 = \omega_i^2 + 2\alpha\theta$

$$\left(\frac{v_0}{r}\right)^2 = 0 + 2\alpha.2\pi n \qquad (\because\ \theta = 2\pi n)$$

$$\alpha = \frac{v_0^2}{4\pi nr^2}\,rad/s^2$$

162. A tractor has its rear wheel with radius 1.0 m and front wheel of radius 0.25 m. The rear wheel is rotating at 100 rev/min. Calculate the angular speed of the front wheel and the distance covered by the tractor in 10 minutes.

(a) 400 rev/min, 6.28×10^3 m
(b) 300 rev/min, 5.17×10^3 m
(c) 200 rev/min, 3.14×10^3 m
(d) 100 rev/min, 1.57×10^3 m

AMU-2019

Ans. (a) : Given, radius of front wheel $(r) = \frac{1}{4}$ meter,

For rear wheel of radius = 1 m, number of revolution per minute(n_i) = 100 rev/min

@apna_pdf

In this condition,

$$v_{front} = v_{rear}$$

$$r_1\,\omega_1 = r_2\,\omega_2$$

$$\frac{1}{4}\times 2\pi n_f = 1\times 2\pi\times 100$$

$$n_f = 400\,\text{rev/min}$$

$\because$ $v = r\omega$

$$v = \frac{1}{4}\times 2\pi\times\frac{400}{60} = \frac{200\pi}{60} = \frac{10}{3}\pi\ \text{m/sec}$$

Distance covered by the tractor in 10 minutes

$$s = vt \qquad \left(\because v = \frac{s}{t}\right)$$

$$s = \frac{10}{3}\pi\times 10\times 60 = 2000\pi = 2000\times 3.14 = 6280$$

$$s = 6.28\times 10^3\ \text{meter}$$

163. A uniform rod of mass 0.5 kg and length 0.5 m is suspended at its ends by means of two light inextensible strings so that the rod is horizontal. If one of the strings is cut, then the angular acceleration of the rod is (Acceleration due to gravity = 10 ms^{-2})

(a) 60 rads^{-2} (b) 30 rads^{-2}

(c) 15 rads^{-2} (d) 10 rads^{-2}

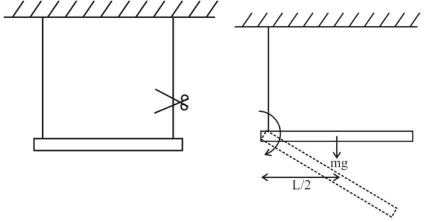
AP EAMCET (Medical)-24.04.2019, Shift-I

Ans. (b) : Given,

m = 0.5 kg

L = 0.5 m = 1/2 m

According to conservation of angular momentum,



$$mg\frac{L}{2} = I\alpha$$

$$\frac{mgL}{2} = \frac{m.L^2}{3}\alpha$$

$$\alpha = \frac{3g}{2L}$$

$$\alpha = \frac{3\times 10}{2\times\frac{1}{2}}$$

$$\alpha = 30\,\text{rad/sec}^2$$

164. A bead is tied on one end of a stiff rope of length 1 m. With the other end of the rope as the centre, the rope is rotated in such a way that the bead completes 10 revolutions per second. The centripetal acceleration of the bead is

(a) 400π^2 m/s^2 (b) 200π^2 m/s^2

(c) 400 m/s^2 (d) 200 m/s^2

(e) 100m/s^2

Kerala CEE-2019

Ans. (a) : Given,

Rope length (r) =1m

Frequency (f) =10 revolution/ second

$\therefore$ Centripetal acceleration,

$$a_c = \frac{v^2}{r} \qquad (\because v = \omega\times r)$$

$$a_c = \frac{\omega^2 r^2}{r} = \omega^2 r$$

$$a_c = (2\pi f)^2\times r \qquad [\because \omega = 2\pi f]$$

Put the value of r and f in above equation

$$a_c = (2\pi 10)^2\times 1$$

$$a_c = 400\pi^2\,\text{m/s}^2$$

165. A body is moving with a constant speed 'v' in a circle of radius r. Its angular acceleration is ____

(a) vr (b) zero

(c) v/r (d) v/r^2

SRMJEE-2019

Ans. (b) : Constant velocity implies constant angular velocity.

We know,

$$\omega = \frac{v}{r}$$

Where given,

v = constant velocity

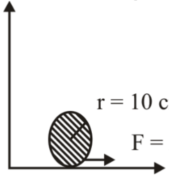
r = radius that is constant

So, $\omega = 0$

Hence,

Angular acceleration is zero.

166. Find ratio of acceleration and angular acceleration of centre of mass of disc if for the given diagram m = 2 kg and r = 10 cm



(a) $\frac{1}{5}$ (b) $\frac{1}{10}$

(c) $\frac{1}{15}$ (d) $\frac{1}{20}$

AIIMS-25.05.2019(M) Shift-1

Ans. (d) : Given that,

F = 20 N

m = 2 kg

r = 10 cm

We know that,

$$a = \frac{F}{m}$$

$$a = \frac{20}{2} \qquad (\because g = 10\text{m/s}^2)$$

$$a = 10\,\text{m/sec}^2$$

@apna_pdf

Angular acceleration,

$$\tau = I.\alpha$$

$$F \times r = \frac{1}{2} mr^2 \times \alpha$$

$$20 \times 0.1 = \frac{1}{2} \times 2 \times (0.1)^2 \times \alpha$$

$$\alpha = 200 \text{ rad/sec}^2$$

$$\therefore \quad \frac{\text{Ratio of acceleration}(a)}{\text{Ratio of Angular acceleration}(\alpha)} = \frac{10}{200}$$

$$\frac{a}{\alpha} = \frac{1}{20}$$

167. A ball of mass 160 g is thrown up at a angle of 60° to the horizontal at a speed of 10 ms^{-1}. The angular momentum of the ball at the highest point of the trajectory with respect to the point from which the ball is thrown is nearly (g = 10 ms^{-2})

(a) 1.73 kg m^2/s
(b) 3.0 kg m^2/s
(c) 3.46 kg m^2/s
(d) 6.0 kg m^2/s

AIIMS-25.05.2019(E) Shift-2

Ans. (b) : Given that,

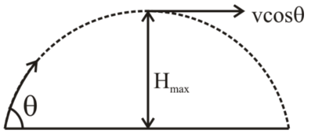
$m = 160$ g

$m = 0.160$ kg

$\theta = 60^\circ$

$v = 10$ m/sec

$g = 10$ m/sec^2



We know, Angular momentum

$$L = \vec{r} \times m\vec{v}$$

$$L = mvr\cos\theta$$

$$L = m(v\cos\theta)H_{max}$$

$$L = mv\frac{v^2\sin^2\theta}{2g}\cos\theta \quad \left[\therefore H_{max} = \frac{v^2\sin^2\theta}{2g}\right]$$

$$L = 0.16 \times 10 \times \frac{(10)^2 \times \sin^2 60^\circ \times \cos 60^\circ}{2 \times 10}$$

$$L = 3 \text{ kg m}^2\text{/sec}$$

168. A particle moves along a circle of radius $\frac{20}{\pi}$ m with constant tangential acceleration. If the velocity of the particle is 80 m s^{-1} at the end of the second revolution after motion has begun, the tangential acceleration is

(a) 640π m s^{-2}
(b) 140π m s^{-2}
(c) 40π m s^{-2}
(d) 40m s^{-2}

COMEDK 2019

Ans. (d) : Given that,

$$r = \frac{20}{\pi}, \; v = 80 \text{ m/sec}$$

In two revolution,

$$\text{Distance (s)} = 2 \times 2\pi r = 2 \times 2 \times \pi \times \frac{20}{\pi} = 80 \text{ m}$$

We know

$v^2 = u^2 + 2as$ (initial velocity is zero)

$\because \quad v^2 = 2as$

$$a = \frac{v^2}{2s}$$

$$a = \frac{80 \times 80}{2 \times 80}$$

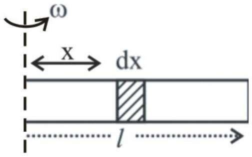
$$a = 40 \text{ m/sec}^2$$

169. A uniform rod of length l and density ρ is revolving about a vertical axis passing through its one end. If ω is the angular velocity of the rod then the centrifugal force per unit area of the rod is

(a) $\frac{\rho\omega^2 l^2}{4}$
(b) $\frac{\rho\omega^2 l^2}{12}$
(c) $\frac{\rho\omega^2 l^2}{2}$
(d) $\frac{\rho\omega^2 l^2}{8}$

AP EAMCET (21.04.2019) Shift-II

Ans. (c) :



Centrifugal force per unit area of rod for small length dx is

$$\int_0^F dF = \int_0^l \frac{m\omega^2 dx}{A} \quad \text{....(i)}$$

Let A is the area of rod and x is variable length of the rod.

Then density of rod,

$$\rho = \frac{m}{A.x} \text{ or } m = \rho Ax$$

putting the value of m in equation (i), we get

$$F = \rho\frac{\omega^2}{A}\int_0^l A.x.dx$$

$$F = \rho\,\omega^2\left(\frac{x^2}{2}\right)_0^l = \frac{\rho\omega^2 l^2}{2}$$

$$F = \frac{\rho\omega^2 l^2}{2}$$

170. If a rigid body is rotating about an axis with a constant velocity, then

(a) Velocity, angular velocity of all particles will be same
(b) Velocity, angular velocity of all particles will be different

@apna_pdf

(c) Velocity of all particles will be different but angular velocity will be same
(d) Angular velocity of all particles will be different but velocity will be same

BITSAT-2019

Ans. (c) : If a rigid body is rotating about an axis with a constant velocity then velocity of all particle will be different but angular velocity will be same

171. An elevator is going up with an acceleration 2 m/s^2. If radius of the wheel attached to the elevator is 0.1 m, then find out number of revolutions in t = 10 s.

(a) 129 (b) 139
(c) 159 (d) 179

AIIMS-27.05.2018(M)

Ans. (c) : Given that,

$a = 2\ \text{m/sec}^2$
$r = 0.1\ \text{m}$
$t = 10\ \text{sec}$

We know,

$\theta = 2\pi n$

and $\theta = \frac{1}{2}\alpha t^2$ [If initial speed is zero]

$$n = \frac{1}{2}\left(\frac{a}{r}\right)\frac{t^2}{2\pi} \quad \left[\because \alpha = \frac{a}{r}\right]$$

$$n = \frac{1}{2}\left(\frac{2}{0.1}\right)\frac{(10)^2}{6.28}$$

$$n = 159.23$$

Number of revolution,

$n = 159$

172. Consider a wheel rotating around a fixed axis. If the rotation angle θ varies with time as θ = at^2, then the total acceleration of a point A on the rim of the wheel is (v being the tangential velocity)

(a) $\frac{v}{t}\sqrt{1+4a^2t^4}$ (b) $\frac{v}{t}$
(c) $\frac{v}{t}\left(1+4a^2t^4\right)$ (d) $\sqrt{\left(1+4a^2t^4\right)}$

TS-EAMCET-05.05.2018, Shift-1

Ans. (c) : Given,

$\theta = at^2$

$$\text{Angular velocity } (\omega) = \frac{d\theta}{dt} = 2at$$

$$\text{Angular acceleration } (\alpha) = \frac{d\omega}{dt} = 2a$$

Tangential linear acceleration,

$a_t = \alpha R$
$a = 2aR$ ....(i)

Radial or normal acceleration of particle

$a_r = \omega^2 R$
$= (2at)^2 R$
$a_r = 4a^2t^2R$ ....(ii)

From equation (i) and (ii)

$$a_{total} = \sqrt{a_t^{\,2} + a_r^{\,2}} = \sqrt{(2aR)^2 + \left(4a^2t^2R\right)^2}$$

$$a_{total} = 2aR\ \sqrt{1+4a^2t^4} \quad \left[\because 2aR = \frac{v}{t}\right]$$

$$\therefore \quad a_{total} = \frac{v}{t}\sqrt{1+4a^2t^4}$$

173. The angular speed of second's hand of the clock is

(a) $\frac{\pi}{1800}\text{rad s}^{-1}$ (b) $\frac{\pi}{30}\text{rad s}^{-1}$
(c) $\frac{\pi}{90}\text{rad s}^{-1}$ (d) $\frac{\pi}{60}\text{rad s}^{-1}$

JCECE-2018

Ans. (b) : Given,

Speed of second hand of the clock
t = 60 sec.
θ = 2π rad

$$\text{Angular speed } (\omega) = \frac{\text{Angular displacement }(\theta)}{\text{time}(t)}$$

$$= \frac{2\pi}{60}$$

$$\omega = \frac{\pi}{30}\text{rad/sec}$$

174. A solid body rotates an angle θ about a stationary axis according to the law θ = 6t – 2t^3. What is the mean value of angular velocity over the time interval between t = 0 and the time when the body comes to rest?

(a) 1 rad/s (b) 2 rad/s
(c) 3 rad/s (d) 4 rad/s

UPSEE - 2018

Ans. (d) : Given that,

$\theta = 6t - 2t^3$ ....(i)

Differentiating with respect to t on both side of the equation–

$$\frac{d\theta}{dt} = \omega = 6 - 6t^2$$

$$6 - 6t^2 = 0$$

$$t^2 = 1$$

t = 1 sec.

Put the value of t in equation (i) we get –

$\theta = 6 \times 1 - 2 \times 1^3$
$\theta = 6 - 2$
$\theta = 4$ rad

For $\theta_0 = 6 \times 0 - 2 \times 0^2$ $[\because t_0 = 0]$
$\theta_0 = 0$ rad

$$\text{Mean value of angular velocity } \omega = \frac{\theta - \theta_0}{t - t_0} = \frac{4-0}{1-0}$$

$\omega = 4$ rad/ sec

@apna_pdf

175. A wheel rotating at 12 rev/s is brought to rest in 6 s. The average angular deceleration in rad/s^2 of the wheel during this process is

(a) 4π (b) 4

(c) 72 (d) $1/\pi$

(e) π

Kerala CEE - 2017

Ans. (a) : Given ;

$\omega_i = 2\pi N$

$\omega_i = 2\pi \times 12$ rad/sec

$\omega_i = 24\pi$ rad/sec

$t = 6$ sec, $\omega_f = 0$

From,

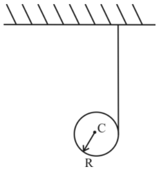
$\omega_f = \omega_i - \alpha\Delta t$

$$\alpha = \frac{\omega_i}{\Delta t}$$

$$= \frac{24\pi}{6}$$

$\alpha = 4\pi$ rad/sec^2

176. A uniform disc of mass M and radius R has a string wound around its periphery and tied to a ceiling as shown in the figure. The acceleration of the center of mass after it is released

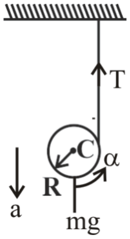


(a) g (b) $\frac{g}{3}$

(c) $\frac{2g}{3}$ (d) $\frac{g}{2}$

TS EAMCET(Medical)-2017

Ans. (c) :



Let us consider

Equation of motion of the disc

$Ma = Mg - T$ ...... (i)

Also torque about O.

$TR = I\alpha$

$\therefore$ $TR = \left(\frac{1}{2}MR^2\right)\alpha$

For no slipping, $a = \alpha R \Rightarrow \alpha = \frac{a}{R}$

We get, $T = \frac{Ma}{2}$ ....(ii)

From equation (i) and (ii), $Ma = Mg - \frac{Ma}{2}$

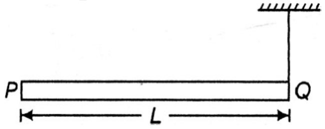
$$ma = m\left(g - \frac{a}{2}\right)$$

$$a + \frac{a}{2} = g$$

$$\frac{2a + a}{2} = g$$

$$a = \frac{2g}{3}$$

177. A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a massless string tied to point Q as shown in figure.



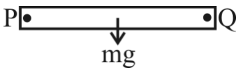
When string is cut, the initial angular acceleration of the rod is–

(a) $\frac{3g}{2L}$ (b) $\frac{g}{L}$

(c) $\frac{2g}{L}$ (d) $\frac{2g}{2L}$

BCECE-2017

Ans. (a) :



(Free body diagram)

angular torque, $\tau = I\alpha$

Moment of inertia (I) about the point Q on the rad,

$I = \frac{mL^2}{3}$ ....(i)

Torque due to weight,

$\tau = mg\left(\frac{L}{2}\right)$ ....(ii)

So, putting the value of τ and I in $\tau = I\alpha$ -

$$mg\left(\frac{L}{2}\right) = \frac{mL^2}{3}\alpha$$

$$\alpha = \frac{3}{2}\frac{g}{L}$$

$$\alpha = \frac{3g}{2L}$$

178. Which one of the following is the correct relation between frequency *f* and angular frequency ω?

(a) $f = \pi\omega$ (b) $\omega = 2\pi f$

(c) $f = 2\omega/\pi$ (d) $f = 2\pi\omega$

NDA (I) 2017

Ans : (b) We know that,

Angular frequency (ω) = $2\pi f$

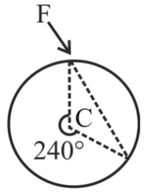
Where f = frequency

S.I. unit of frequency is hertz (Hz)

S.I. unit of angular frequency is rad/sec

@apna_pdf

179. A uniform disc of mass M and radius R is hinged at its centre C. A force F is applied on the disc as shown. At this instant, angular acceleration of the disc is

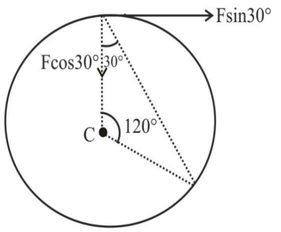


(a) $\sqrt{3}\frac{F}{MR}$ (b) $\frac{F}{MR}$

(c) $\frac{2}{\sqrt{3}}\frac{F}{MR}$ (d) $\frac{F}{2MR}$

UPSEE - 2017

Ans. (b) :



For Disc,

M = mass of disc
R = Radius of disc
F = Applied Force

We know that,

$$\tau = I\alpha$$

$$F \times R \times \sin 30^\circ = \frac{MR^2}{2}\alpha$$

$$F \times \frac{1}{2} \times R = \frac{MR^2}{2}\alpha$$

$$\therefore \quad \alpha = \frac{F}{MR}$$

180. A wheel is rotating at 1800 rpm about its own axis. When the power is switched off, it comes to rest in 2min. Then, the angular retardation in rad/s^2 is

(a) 2 π (b) π

(c) π/2 (d) π/4

(e) π/6

Kerala CEE- 2014

Ans. (c) : Given that,

$\omega_0 = 0$
N = 1800 rpm
t = 2 min = 120 sec

So,

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 1800}{60} = 60\pi$$

Applying first equation of rotational motion –

$$\omega = \omega_0 + \alpha \times t$$

$$\omega = \alpha \times t \qquad [\because \omega_0 = 0]$$

$$\alpha = \frac{\omega}{t}$$

$$\alpha = \frac{60\pi}{120} \qquad [\because \omega = 60\pi]$$

$$\alpha = \frac{\pi}{2}\text{rad/sec}^2$$

181. The principle involved in the performance of a spinning-chair circus acrobat is

(a) conservation of angular momentum
(b) conservation of linear momentum
(c) conservation of energy
(d) principle of moment
(e) work-energy principle

Kerala CEE- 2013

Ans. (a) The principle of conservation of angular momentum involved in the performance of a spinning chair circus acrobat.

182. A particle describes uniform circular motion in a circle of radius 2 m, with the angular speed of 2 rad s^{-1}. The magnitude of the change in its velocity in $\frac{\pi}{2}$ s is

(a) 0 ms^{-1} (b) $2\sqrt{2}$ ms^{-1}

(c) 8 ms^{-1} (d) 4 ms^{-1}

(e) $4\sqrt{2}$ ms^{-1}

Kerala CEE- 2013

Ans. (c) : Given that,

Angular speed (ω) = 2 rad/sec
Radius (r) = 2 m
Time (t) = $\frac{\pi}{2}$ sec

Angle moved in time t,

$$\theta = \omega t = 2 \times \frac{\pi}{2} = \pi \text{ rad.}$$

Now,

Angular velocity (v) = ωr

$$= 2 \times 2$$

$$v = 4 \text{ m/sec}$$

The magnitude of the change in velocity,

$$\Delta v = 2v\sin\frac{\theta}{2}$$

$$\Delta v = 2 \times 4 \times \sin\frac{\pi}{2}$$

$$\Delta v = 8 \times 1$$

$$\Delta v = 8 \text{ m/sec}$$

183. The angular velocity of a wheel increases from 100 rps to 300 rps in 10 s. The number of revolutions made during that time is

(a) 600 (b) 1500

(c) 1000 (d) 3000

(e) 2000

Kerala CEE - 2008

@apna_pdf

Ans. (e) : Given that,

$N_1 = 100$ rps, $N_2 = 300$ rps

$t = 10$sec

We know,

$$\omega = 2\pi N$$

$$\omega_i = 2\pi \times 100 = 200\pi$$

$$\omega_f = 2\pi \times 300 = 600\,\pi$$

Now, $\omega_f = \omega_i + \alpha t$

$$600\,\pi = 200\,\pi + 10\alpha$$

$$400\pi = 10\,\alpha$$

$$\alpha = 40\,\pi$$

From equation of motion-

$$(\omega_f)^2 = (\omega_i)^2 + 2\alpha\theta$$

So,

$$(600\,\pi)^2 = (200\pi)^2 + 2\times 40\pi \times \theta$$

$$\pi^2\,(360000 - 40000) = 80\pi\theta$$

$$320000\pi = 80\,\theta$$

$$4000\,\pi = \theta$$

So,

$$\text{Number of revolutions} = \frac{\theta}{1\text{ revolution angle}(2\pi)}$$

$$= \frac{4000\pi}{2\pi} = 2000$$

184. A particle of mass m = 5 units is moving with a uniform speed v = $3\sqrt{2}$ m in the XOY plane along the line Y = X + 4. The magnitude of the angular momentum about origin is :

(a) zero
(b) 60 unit
(c) 7.5 unit
(d) $40\sqrt{2}$ unit
(e) 3.0 unit

Kerala CEE 2006

Ans. (b) : Given that,

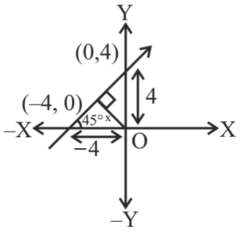
$$v = 3\sqrt{2}\,\text{m}$$

$$Y = X + 4$$

Comparing above equation with Y = tanθ X + c,

$$\tan\theta = 1$$

$$\theta = 45°$$



We know that,

$$L = mvr_\perp$$

Now, from diagram,

$$\sin 45° = \frac{x}{4}$$

$$x = 4\sin 45°$$

$$x = 4 \times \frac{1}{\sqrt{2}}$$

$$x = 2\sqrt{2}$$

So,

$$L = mv \times x$$

$$L = 5\times 3\sqrt{2}\times 2\sqrt{2} \qquad \{r_\perp = x\}$$

$$L = 60\text{ unit}$$

185. If the length of the second's hand in a stop-clock is 3cm, the angular velocity and linear velocity of the tip is:

(a) 0.2047 rad/s, 0.0314 ms^{-1}
(b) 0.2547 rad/s, 0.314 ms^{-1}
(c) 0.1472 rad/s, 0.06314 ms^{-1}
(d) 0.1047 rad/s, 0.00314 ms^{-1}
(e) 0.347 rad/s, 0.314 ms^{-1}

Kerala CEE 2005

Ans. (d) : Given that,

Length of the second's hand in a stop-clock = 3 cm

Angular velocity of the tip –

$$\omega = \frac{2\pi}{t} = \frac{2\pi}{60} = \frac{\pi}{30} = \frac{3.14}{30}$$

$$= 0.1047\text{ radsec}^{-1}.$$

Linear velocity, v = r ω

$$= 3 \times 10^{-2} \times 0.1047$$

$$= 0.00314\text{ m/sec}$$

186. A motor is rotating at a constant angular velocity of 500 rpm. The angular displacement per second is:

(a) $\frac{3}{50\pi}$rad
(b) $\frac{3\pi}{50}$rad
(c) $\frac{25\pi}{3}$rad
(d) $\frac{3\pi}{25}$rad
(e) $\frac{50\pi}{3}$rad

Kerala CEE 2004

Ans. (e) : Given that,

N = 500 rpm

The angular displacement per second, $\theta = \omega t$ rad

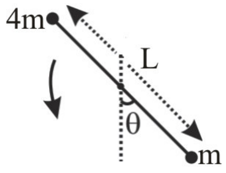
$$= 2\pi N \times \frac{1}{60}$$

$$= \frac{2\pi\times 500}{60}$$

$$\therefore \quad \theta = \frac{50\pi}{3}\text{rad}$$

187. Two balls of mass m and 4m are connected by a rod of length L. The mass of the rod is small and can be treated as zero. The size of the balls also can be neglected. We also assume the centre of the rod is hinged, but the rod can rotate about its centre in the vertical plane without friction. What is the gravity induced angular acceleration of the rod when the angle between the rod and the vertical line is θ as shown.

@apna_pdf

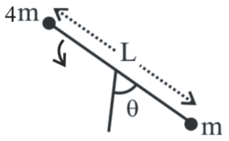


(a) $\frac{5g}{6L}\sin\theta$ (b) $\frac{g}{6L}\cos\theta$

(c) $\frac{6g}{5L}\sin\theta$ (d) $\frac{g}{3L}\sin\theta$

UPSEE - 2016

Ans. (c) :



$$I = 4m\left(\frac{L}{2}\right)^2 + m\left(\frac{L}{2}\right)^2$$

$$= \frac{5}{4}mL^2$$

Now net torque on the connected rod of the length L,

$$\tau = 4mg\frac{L}{2}\sin\theta - mg\frac{L}{2}\sin\theta$$

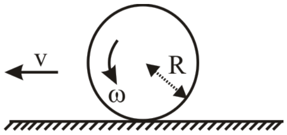
$$\tau = 3mg\frac{L}{2}\sin\theta$$

We know,

$$\tau = I\alpha$$

$$\alpha = \frac{\tau}{I} = \frac{3mg\frac{L}{2}\sin\theta}{\frac{5}{4}mL^2} = \frac{6g\sin\theta}{5L}$$

188. A tire of radius R rolls on a flat surface with angular velocity ω and velocity v as shown in the diagram. If v > ωR, in which direction does friction from the tire act on the road?

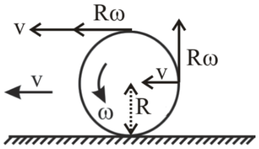


(a) Towards downwards (b) Towards upwards

(c) Towards the left (d) Towards the right

UPSEE - 2016

Ans. (c) :



When the tire has higher speed and applied sudden break (v > Rω) then the tire rub the road surface and rolling with forward slipping.

So, the friction acting opposite direction of v or toward left in the given situation.

189. When a ceiling fan is switched off, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest?

(a) 24 (b) 36

(c) 18 (d) 12

UPSEE - 2008

Ans. (d) : Given that,

$\omega = \omega_0/2$, Number of rotation (n) = 36

We can write the equation of motion for circular motion as –

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

When fan switched off velocity becomes half and number of rotation (n) = 36

$$\left(\frac{\omega_0}{2}\right)^2 = \omega_0^2 + 2\alpha(2\pi n)$$

$$\frac{\omega_0^2}{4} = \omega_0^2 + 2\alpha(2\pi\times 36)$$

$$\therefore \alpha = \frac{-3}{4}\times\frac{\omega_0^2}{4\pi\times 36}$$

Let fan complete total n' revolutions from the starting to come to rest

$$\omega^2 = \omega_0^2 - 2\alpha(2\pi n')$$

$$0 = \omega_0^2 - 4\alpha\pi n'$$

$$n' = \frac{\omega_0^2}{4\alpha\pi} \quad \text{....(i)}$$

Put the value of α in eq^n (i) we get –

$$n' = \frac{\omega_0^2}{4\times\frac{-3}{4}\times\frac{\omega_0^2}{4\pi\times 36}\times\pi}$$

$$n' = \frac{\omega_0^2}{4\pi}\times\frac{4\times 4\pi\times 36}{3\omega_0^2}$$

n' = 48 revolutions

∴ Required number of rotation = n' – n

= 48 – 36 = 12

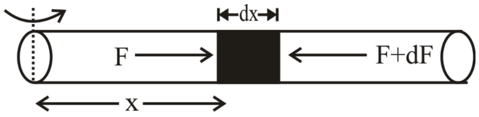
190. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end will be

(a) $\frac{1}{2}M^2\omega^2L$ (b) $\frac{1}{2}M\omega^2L$

(c) $\frac{1}{2}M\omega^2L^2$ (d) None of these

UPSEE - 2008

Ans. (b) : Suppose the length of a small element of tube be dx.



@apna_pdf

Mass of this element, $dm = \frac{M}{L}dx$

M = mass of filled liquid
L = length of tube

Applied force on the tube,

$$dF = (dm)\omega^2 x = \left(\frac{M}{L}\right) dx.\ \omega^2 x \qquad ....(i)$$

Integrating eq^n. (i) we get –

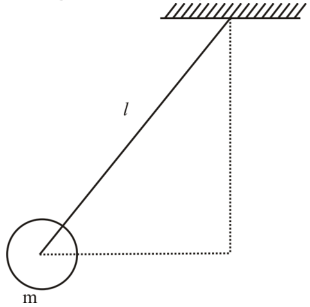
$$\int_0^F dF = \frac{M}{L}\omega^2 \int_0^L x dx$$

$$F = \frac{M}{L}\omega^2\left[\frac{x^2}{2}\right]_0^L$$

$$F = \frac{M}{L}\omega^2\left[\frac{L^2}{2}\right] = \frac{ML\omega^2}{2}$$

$\therefore \qquad F = \frac{1}{2}ML\omega^2$

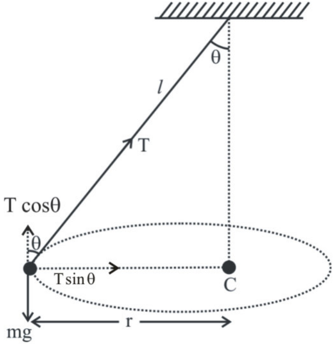
191. A ball of mass M=0.5 kg is attached to one end of a string of length L=0.5 m. The ball rotates circularly in horizontal plane along vertical axis. If maximum tension which can be applied on string is 324 N, what will be the maximum expected angular velocity of the ball?



(a) 9 rad/s (b) 18 rad/s
(c) 27 rad/s (d) 36 rad/s

CG PET -2016

Ans. (d) : Given, m = 0.5 kg, r = 0.5 m, T = 324 N



Radius of the horizontal circular path -

$r = l \sin\theta$

Tcosθ component will balance the weight mg, since particle's acceleration in y direction is zero.

$T\cos\theta = mg$

T sin θ component will provide necessary centripetal force to the ball towards center.

$\therefore \qquad T\sin\theta = mr\omega^2 = m(l\sin\theta)\omega^2$

$T = ml\omega^2$

$\therefore \qquad \omega = \sqrt{\frac{T}{ml}}$

$$\omega_{max} = \sqrt{\frac{T_{max}}{ml}} = \sqrt{\frac{324}{0.5\times0.5}} = 36 \text{ rad/s}$$

192. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Two objects each of mass m are attached gently on the opposite ends of the diameter of the ring. The angular velocity of the ring now will be

(a) ω (b) $\frac{M+2m}{M}\omega$
(c) $\frac{\omega M}{m}$ (d) $\frac{\omega M}{M+2m}$

CG PET- 2015

Ans. (d) : Given,

Radius of circular ring = R

Initial angular velocity of ring $(\omega_1) = \omega$

Initial moment of inertia $(I_1) = Mr^2$

Now, for object of mass m are attached to ring then final moment of inertia-

$I_2 = Mr^2 + 2mr^2$
$= r^2(M + 2m)$

Let ω_2 be the final angular velocity of ring using conservation of angular moment

$I_1\omega_1 = I_2\omega_2$

$Mr^2\omega = (M + 2m)r^2\omega_2$

$$\omega_2 = \frac{M\omega}{M+2m}$$

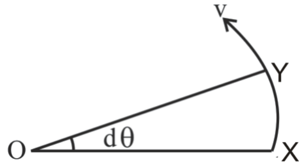
193. A particle is moving along a circular path with uniform speed. Through what angle does it angular velocity change when it completes half of the circular path?

(a) 0º (b) 45º
(c) 180º (d) 360º

JCECE-2011

Ans. (a) : We know that,

$$\text{Angular velocity}(\vec{\omega}) = \frac{\overrightarrow{d\theta}}{\overrightarrow{dt}}$$



Where $\overrightarrow{d\theta}$ is angular displacement

Angular velocity is a vector quantity. Angular velocity is always directed perpendicular to the plane of circular path.

Hence, required change in angle is zero because, direction of angular velocity is not change.

@apna_pdf

194. The motor of an engine is rotating about its axis with an angular velocity of 100 rev/m. It comes to rest in, 15s, after being switched off. Assuming constant angular deceleration. What are the numbers of revolutions made by it before coming to rest?

(a) 12.5 (b) 40
(c) 32.6 (d) 15.6

JCECE-2011

Ans. (a) : Given that,

$\omega_0 = 100$ rev/m

$t = 15$ sec

Final angular velocity, $\omega = 0$

We know that,

$\omega = \omega_0 - \alpha t$

$0 = \omega_0 - \alpha t$

$\omega_0 = \alpha t$

$$\alpha = \frac{100\times 2\pi}{60\times 15}$$

$\alpha = 0.7$ rad/sec

Now angle rotated before coming to rest

$$\omega^2 = \omega_0^2 - 2\alpha\theta \qquad (\omega = 0)$$

$$\theta = \frac{\omega_0^2}{2\alpha} = \frac{\left(\frac{100\times 2\pi}{60}\right)^2}{2\times 0.7}$$

$\theta = 78.30$ rad

Number of Rotation,

$$n = \frac{\theta}{2\pi} = \frac{78.30}{2\pi}$$

$n = 12.5$

195. A flywheel rotates about an axis. Due to friction at the axis, it experiences an angular retardation proportional to its angular velocity. If its angular velocity falls to half while it makes n rotations, how many more rotations will it make before coming to rest?

(a) 2n (b) n
(c) n/2 (d) n/3

AIIMS-2013

Ans. (b) : According to question, α is proportional to ω

$\alpha \propto -\omega$

$\alpha = -k\omega$

$$\omega\frac{d\omega}{d\theta} = -k\omega$$

$$\int_{\omega_0}^{\omega_0/2} d\omega = -k\int_0^{2\pi n} d\theta$$

$$\frac{\omega_0}{2} - \omega_0 = -k(2\pi n) \qquad ....(i)$$

$$\int_{\omega_0}^{0} d\omega = -k\int_0^{2\pi(n+n')} d\theta$$

$$0 - \omega_0 = -k2\pi(n+n') \qquad ....(ii)$$

From equation (i) and (ii) we get,

$$\frac{n+n'}{n} = 2$$

$n' = n$

196. A circular disc rotating with frequency $f_0 = 1.3$ rev/sec comes to a stop in 30 seconds. The approximate angular acceleration is:

(a) -0.54 rad/sec^2 (b) -0.27 rad/sec^2
(c) $+0.54$ rad/sec^2 (d) $+0.27$ rad/sec^2

AIIMS-2011

Ans. (b) : Given that,

$f_0 = 1.3$ rev/sec

$t = 30$ sec

We know,

$\omega_0 = 2\pi f_0$

$\omega_0 = 2\pi \times 1.3$

$\omega_0 = 2.6\,\pi$ rad/sec

Using first equation of motion,

$\omega = \omega_0 + \alpha t$

$0 = 2.6\pi + \alpha \times 30$

$$\alpha = \frac{-2.6\pi}{30}$$

$\alpha = -0.27$ rad/sec^2

197. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.00 rad/s. In a time of 2 s it has rotated through an angle (in radian) of

(a) 6 (b) 10
(c) 12 (d) 4

AIIMS-2008

Ans. (b) : Given that,

$\omega_0 = 2$ rad/s

$\alpha = 3$ rad/s^2

$t = 2$ sec

From second equation of motion,

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = (2\times 2) + \frac{1}{2}\times 3\times (2)^2$$

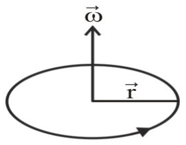
$\theta = 10$ radian

198. The direction of the angular velocity vector along:

(a) The tangent to the circular path
(b) The inward radius
(c) The outward radius
(d) The axis of rotation

AIIMS-2007, 2004

Ans. (d) :



Angular velocity is a vector whose direction is perpendicular to the plane of circular path or axis of rotation. Its direction has been shown in the figure.

@apna_pdf

199. If the equation for the displacement of particle moving on a circular path is given as $\theta = 2t^3 + 0.5$,
Where θ is in radians and t is in second. Then the angular velocity of the particle after two second will be:

(a) 36 rad/sec (b) 8 rad/sec
(c) 48 rad/sec (d) 24 rad/sec

AIIMS-1998

Ans. (d) : Given that,

$$t = 2\text{sec}$$
$$\theta = 2t^3 + 0.5$$

We know,

$$\omega = \frac{d\theta}{dt}$$

then, $\omega = 6t^2$

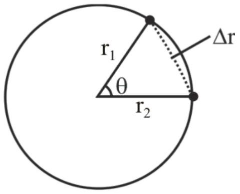
$$\omega = 6\times(2)^2$$
$$\omega = 24 \text{ rad/sec}$$

200. A particle moves through angular displacement θ on a circular path of radius r. The linear displacement will be–

(a) $2r\sin\left(\frac{\theta}{2}\right)$ (b) $2r\cos\left(\frac{\theta}{2}\right)$
(c) $2r\tan\left(\frac{\theta}{2}\right)$ (d) $2r\cot\left(\frac{\theta}{2}\right)$

BCECE-2014

Ans. (a): It is the shortest distance b/w initial point and final point



$$\vec{r}_1 = \vec{r}_2 + \vec{\Delta}r$$
$$\vec{\Delta}r = \vec{r}_1 - \vec{r}_2$$
$$|\vec{\Delta}r| = |\vec{r}_1 - \vec{r}_2| \qquad \{\because |r_1| = |r_2| = r\}$$
$$|\vec{\Delta}r| = \sqrt{|r_1|^2 + |r_2|^2 - 2r_1\times r_2\cos\theta}$$
$$|\vec{\Delta}r| = \sqrt{2r^2 - 2r^2\cos\theta}$$
$$|\vec{\Delta}r| = r\sqrt{2(1-\cos\theta)}$$
$$|\vec{\Delta}r| = r\sqrt{2\left(2\sin^2\frac{\theta}{2}\right)}$$
$$|\vec{\Delta}r| = 2r\sin\frac{\theta}{2}$$

201. Shaft of a motor rotates at a constant angular velocity of 3000 rpm. The radians it has turned through in 1s is–

(a) π (b) $10\ \pi$
(c) $50\ \pi$ (d) $100\ \pi$

BCECE-2014

Ans. (d) : Given that,

$$N = 3000 \text{ rpm}$$
$$t = 1\text{sec}$$

We know that,

$$\omega = \frac{2\pi N}{60} = \frac{2\times\pi\times3000}{60} = 100\pi$$

$\because$ $\theta = \omega t$

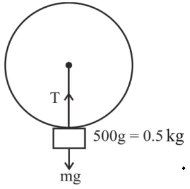
$$\theta = 100\pi\times1$$
$$\theta = 100\pi \text{ rad}$$

202. A weightless thread can bear tension up to 3.7 kg wt. A stone of mass 500g is tied to it and revolved in a circular path of radius 4m in a vertical plane. If $g = 10m/s^2$, then the maximum angular velocity of the stone will be–

(a) 2 rad/s (b) 4 rad/s
(c) 16 rad/s (d) $\sqrt{21}$ rad/s

BCECE-2013

Ans. (b) : Given that, mass (m) = 500 gm = 0.5 kg, g = 10 m/sec^2, radius (r) = 4 m, tension (T) = 3.7 kg = 37 N



$\because$ $T - mg = \frac{mv^2}{r}$

$$T - mg = mr\omega^2 \qquad (\because v = r\omega)$$
$$T = mr\omega^2 + mg$$
$$37 = 0.5\times4\times\omega^2 + 0.5\times10$$
$$37 = 2\ \omega^2 + 5$$
$$16 = \omega^2$$
$$\omega = 4 \text{ rad/sec}$$

203. A car is travelling with linear velocity v on a circular road of radius r. If it is increasing its speed at the rate of a m/s^2, then the resultant acceleration will be–

(a) $\left(\frac{v^2}{r} + a\right)$ (b) $\left(\frac{v^2}{r^2} + a\right)^{1/2}$
(c) $\left(\frac{v^4}{r^2} + a^2\right)^{1/2}$ (d) $\left(\frac{v^2}{r^2} - a^2\right)^{1/2}$

BCECE-2010

Ans. (c) : The car will have two accelerations, centripetal acceleration and tangential acceleration.

Centripetal acceleration $(a_c) = \frac{v^2}{r}$ (towards the centre)

Tangential acceleration (a_t) = a (along tangent)

So, resultant acceleration $(a) = \sqrt{a_c^2 + a_t^2}$

$$a = \sqrt{\frac{v^4}{r^2} + a^2}$$
$$a = \left(\frac{v^4}{r^2} + a^2\right)^{1/2}$$

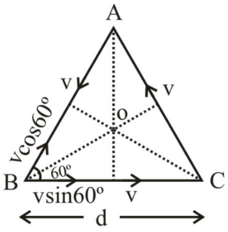
@apna_pdf

204. Three particles A, B, C are situated at the vertices of an equilateral triangle ABC of side d at t = 0. Each of the particles moves with constant speed v. A always has its velocity along AB, B along BC and C along CA. The time the particles meet each other is

(a) d/(3v) (b) 2d/(3v)
(c) 3d/(2v) (d) d/v

SCRA-2010

Ans. (b) :



Velocity of B along BA = $v\cos 60° = \frac{v}{2}$

Thus, separation AB decreases at the rate

$v_{AB} = v_A - v_B$

$$= v - \left(-\frac{v}{2}\right) = \frac{3v}{2}$$

Hence, the time taken in reducing the separation AB from d to zero is

$$\text{Time (t)} = \frac{d}{(3\,v/2)} = \frac{2d}{3v}$$

205. A particle executing SHM has a maximum speed of 0.5 ms^{-1} and maximum acceleration of 1.0 ms^{-2}. The angular frequency of oscillation is:

(a) 2 rad s^{-1} (b) 0.5 rad s^{-1}
(c) 2π rad s^{-1} (d) 0.5 π rad s^{-1}

Karnataka CET-2016

Ans. (a) : Given, $a_{max} = 1.0\,m/s^2, v_{max} = 0.5\,m/s$

We know that, general equation of SHM–

$x = A \sin\omega t$ ....(i)

On differentiating w.r.t. time, we get–

$$v = \frac{dx}{dt} = A\omega\cos\omega t \quad ....(ii)$$

$v_{max} = A\omega$

Again differentiating equation (ii) w.r.t. time

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = -A\omega^2 \sin\omega t$$

$$|a_{max}| = A\omega^2$$

$$\because \text{ Angular frequency } (\omega) = \frac{a_{max}}{v_{max}}$$

$$\omega = \frac{1}{0.5} = 2\text{ rad/s}$$

206. The ratio of angular speed of a second- hand to the hour-hand of a watch is:

(a) 3600 : 1 (b) 720 : 1
(c) 72 : 1 (d) 60 : 1

Karnataka CET-2015

Ans. (b) : We know that, angular speed $(\omega) = \frac{\theta}{t}$

$$\omega \propto \frac{1}{t}$$

Since, $\frac{\omega_{sec}}{\omega_{hour}} = \frac{t_{hour}}{t_{sec}} = \frac{12\times3600}{60} = 720$

$\therefore \quad \frac{\omega_{sec}}{\omega_{hour}} = \frac{720}{1} = 720:1$

207. A rotating wheel changes angular speed from 1800 rpm to 3000 rpm in 20s. What is the angular acceleration assuming to be uniform?

(a) 60 π rad s^{-2} (b) 90 π rad s^{-2}
(c) 2 π rad s^{-2} (d) 40 π rad s^{-2}

Karnataka CET-2014

Ans. (c) : Given, $N_1 = 1800\,rpm$, $N_2 = 3000\,rpm$,

$\Delta t = 20s$

We know that, $\omega = 2\pi N/60$

$\therefore \quad \omega_1 = 2\pi N_1/60$

$$= 2\pi\times\frac{1800}{60} = 2\pi\times30 = 60\pi$$

And, $\omega_2 = \frac{2\pi N_2}{60} = 2\pi\times\frac{3000}{60} = 2\pi\times50 = 100\pi$

From kinematics laws of rotational motion–

$\omega = \omega_0 + \alpha t$ ....(i)

Where, ω = final angular velocity

ω_0 = Initial angular velocity

α = Angular acceleration

t = time

Putting the value of these in equation (i), we get–

$100\pi = 60\pi + \alpha \times 20$

$$\alpha = \frac{40\pi}{20} = 2\pi\,rad/sec^2$$

208. When a ceiling fan is switched off, its angular velocity reduces by 50% while it makes 36 rotations. How many more rotation will it make before coming to rest? (Assume uniform angular retardation):

(a) 36 (b) 48
(c) 18 (d) 12

Karnataka CET-2001

Ans. (d) : Given, ω = 50% of ω_0, total revolution (N) = 36

Total angular displacement (θ) = 36 × 2π

Equation of circular motion–

$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$\therefore \quad \frac{\omega_0^2}{4} = \omega_0^2 - 2\alpha\times36\times2\pi \quad \left(\omega = \frac{\omega_o}{2}\right)$$

$$144\pi\alpha = \omega_0^2 - \frac{\omega_0^2}{4}$$

$$144\pi\alpha = \frac{3\omega_0^2}{4}$$

@apna_pdf

$$\therefore \quad \alpha = \frac{3\omega_0^2}{4\times144\pi} \quad ....(i)$$

Now let fan complete total N_1 revolutions from the starting to come to rest $(\omega = 0)$

$$0 = \omega_0^2 - 2\alpha(2\pi N_1)$$

$$\because \quad N_1 = \frac{\omega_0^2}{4\alpha\pi}$$

Substituting the value of 'α' from equation (i), we get

$$N_1 = \frac{\omega_0^2}{4\pi}\times\frac{4\times144\pi}{3\omega_0^2} = 48\,\text{rotation}$$

Number of rotation = 48 – 36 = 12 rotation

209. How much revolution does the engine make during the time when a motor wheel with angular speed is increased from 720 rpm to 2820 rpm in 14 seconds?

(a) 354 (b) 490
(c) 413 (d) 620

J&K-CET-2014

Ans. (c) : Given, time(t) = 14 sec, N_0 = 720 rpm, N = 2820 rpm

$$\because \quad \omega = 2\pi\times\frac{2820}{60} = 94\pi\text{ rad/s}$$

$$\omega_o = 2\pi\times\frac{720}{60} = 24\pi\text{ rad/s}$$

From kinematics laws of rotational motion

$$\because \quad \omega = \omega_o + \alpha t$$

$$94\pi = 24\pi + \alpha(14)$$

$$\alpha = 5\pi\,\text{rad/s}^2$$

We know that, $\theta = \omega_o t + \frac{1}{2}\alpha t^2$

$$= 24\pi\times14 + \frac{1}{2}\times(5\pi)\times(14)^2$$

$$= 336\pi + 490\pi = 826\pi$$

$$\therefore \text{ Number of revolution } = \frac{826\pi}{2\pi} = 413\,\text{revolution}$$

210. Angular speed of hour of a clock in degree per second is

(a) $\frac{1}{30}$ (b) $\frac{1}{60}$
(c) $\frac{1}{120}$ (d) $\frac{1}{720}$

MHT-CET 2016

Ans. (c) : We know that,

$$\text{Angular speed}(\omega) = \frac{\theta}{t} = \frac{360}{12\times3600}$$

$$= \frac{1}{12\times10} = \frac{1}{120}\text{ degree/sec}$$

211. The difference between angular speed of minute hand and second hand of a clock is

(a) $\frac{59\pi}{900}$ rad/s (b) $\frac{59\pi}{1800}$ rad/s
(c) $\frac{59\pi}{2400}$ rad/s (d) $\frac{59\pi}{3600}$ rad/s

MHT-CET 2014

Ans. (b) :

$$\text{Angular velocity of minute hand}(\omega_1) = \frac{2\pi}{60\times60}$$

$$= \frac{\pi}{1800}\text{ rad/s}$$

$$\text{Angular speed of second hand}(\omega_2) = \frac{2\pi}{60}$$

$$\omega_2 = \frac{\pi}{30}\text{ rad/s}$$

Now, difference between angular speed of minute hand and second hand $(\omega_2 - \omega_1) = \frac{\pi}{30} - \frac{\pi}{1800}$

$$= \frac{60\pi - \pi}{1800} = \frac{59\pi}{1800}\text{ rad/s}$$

212. Angular velocity of hour hand of a watch is

(a) $\frac{\pi}{43200}$ rad s^{-1} (b) $\frac{\pi}{30}$ rad s^{-1}
(c) $\frac{\pi}{21600}$ rad s^{-1} (d) $\frac{\pi}{1800}$ rad s^{-1}

MHT-CET 2005

Ans. (c) : As we know that,
Time taken by hour hand for one rotation is 12 hrs.

$$\therefore \quad \text{Angular velocity, } \omega = \frac{2\pi}{12}\text{ rad/hr}$$

$$= \frac{2\pi}{12\times60\times60}\text{ rad/s}$$

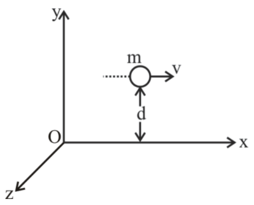
$$= \frac{\pi}{21600}\text{ rad/s}$$

213. A mass M is moving with a constant velocity on a line parallel to the x-axis. Its angular momentum with respect to the origin on z-axis

(a) is zero (b) remains constant
(c) goes on increasing (d) goes on decreasing

Manipal UGET-2011

Ans. (b) :



∵Angular momentum of particle with respect to origin = linear momentum × perpendicular distance of line of action of linear momentum from origin

$$= mv\times d$$

$$= mvd$$

=constant

∴ Angular momentum with respect to origin on z-axis is remain constant.

@apna_pdf

214. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.0 rad/s. In a time of 2 s it has rotated through an angle (in radian) of

(a) 6 (b) 10

(c) 12 (d) 4

UP CPMT-2008

Ans. (b) : Given-

Angular acceleration, $\alpha = 3$ rad /s^2

$\omega_0 = 2$ rad/sec

$t = 2$ sec

From law of angular motion,

$$\therefore \quad \theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = 2 \times 2 + \frac{1}{2} \times 3 \times 2^2$$

$$\theta = 4 + 6$$

$$\theta = 10 \text{ radians}$$

215. The angular speed of a flywheel making 360 rev/min is

(a) 12π (b) 6π

(c) 3π (d) 2π

UP CPMT-2010

Ans. (a) : Given,

Number of revolutions per minute,

$N = 360$ rpm

$$\therefore \quad \text{angular speed } (\omega) = \frac{2\pi N}{60}$$

$$= \frac{2\pi \times 360}{60}$$

$$= 12\pi \ \ \text{rad/s}$$

216. The angular velocity of second hand of a clock is

(a) $\left(\frac{\pi}{6}\right) \text{rad s}^{-1}$ (b) $\left(\frac{\pi}{60}\right) \text{rad s}^{-1}$

(c) $\left(\frac{\pi}{30}\right) \text{rad s}^{-1}$ (d) $\left(\frac{\pi}{15}\right) \text{rad s}^{-1}$

UP CPMT-2003

Ans. (c) : We know that,

A second hand makes an angle of 2π in 60 sec. Now,

Angular velocity, $\omega = \frac{\theta}{t}$

$$= \frac{2\pi}{60}$$

$$= \left(\frac{\pi}{30}\right) \text{rad s}^{-1}$$

217. A coin placed on a rotating turn-table slips, when it is placed at a distance of 9 cm from the centre. If the angular velocity of the turn-table is tripled, it will just slip at a distance r from centre. The value of r is

(a) 1 cm (b) 3 cm

(c) 9 cm (d) 27 cm

UP CPMT-2001

Ans. (a) : Given that,

$\omega_1 = \omega$ $\quad\omega_2 = 3\omega$

$r_1 = 9$ cm $\quad r_2$?

We know that in the given condition friction provides the required centripetal force and that is constant,

$$mr\omega^2 = \text{constant}$$

$$\Rightarrow \quad r \propto \frac{1}{\omega^2}$$

$$\Rightarrow \quad \frac{r_1}{r_2} = \left(\frac{\omega_2}{\omega_1}\right)^2$$

$$\frac{r_2}{r_1} = \left(\frac{\omega_1}{\omega_2}\right)^2$$

$$r_2 = r_1\left(\frac{\omega_1}{\omega_2}\right)^2$$

$$= 9\left(\frac{\omega}{3\omega}\right)^2$$

$$= 9 \times \frac{1}{9} = 1$$

$r = 1$ cm $\quad\{r_2 = r\}$

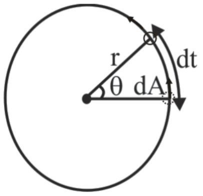
218. A particle of mass 'm' is revolving in a horizontal circle of radius r with a constant angular speed ω. The areal velocity of the particle is

(a) $r^2\omega$ (b) $r^2\theta$

(c) $\frac{r^2\omega}{2}$ (d) $\frac{r\omega^2}{2}$

SRM JEE - 2007

Ans. (c) : Particle is moving in a horizontal circle of radius r. Let θ be the angular displacement of the particle after time dt as shown in the figure.



Area covered in time dt is given by,

$$dA = \frac{\pi r^2 \theta}{2\pi}$$

Areal velocity,

$$V_A = \frac{dA}{dt} = \frac{dA}{d\theta} \times \frac{d\theta}{dt}$$

$$v_A = \frac{1}{2} r^2 \omega \qquad \left(\because \frac{d\theta}{dt} = \omega\right)$$

219. A circular disc is rotating with angular velocity ω. A man standing at the edge walks towards the centre of the disc then the angular velocity of the system

(a) Decreases (b) Increases

(c) No change (d) Halved

SRM JEE - 2009

@apna_pdf

Ans. (b) : Angular momentum of a particle is L = Iω
Here, angular momentum will be conserved as there is no external torque. Now, as man moves towards the centre of the disc moment of inertia decreases ($I \propto R^2$) hence angular velocity increases.

220. A scooter is going round a circular road of radius 200 m at a speed of 20 m/s. The angular speed of scooter will be

(a) 1 radian/sec (b) 0.01 radian/sec
(c) 0.1 radian/sec (d) 10 radian/sec

SRMJEE - 2014

Ans. (c) : Given,
Radius of the circular road, r = 200 m
Speed of scooter, v = 20 m/s
Angular speed of scooter will be given by

$$v = r\omega \Rightarrow \omega = \frac{v}{r}$$

$$\Rightarrow \quad \omega = \frac{20}{200}\text{rad/sec}$$

$$\Rightarrow \quad \omega = 0.1\text{ rad/sec}$$

221. When a ceiling fan is switched on, it makes 10 revolution in the first 3 s. Assuming a uniform angular acceleration, how many rotation it will make in the next 3 s

(a) 10 (b) 20
(c) 30 (d) 40

JIPMER-2012

Ans. (c) : The ceiling fan makes 10 revolution in the first 3 second
$\theta_1 = 2\pi\times10 = 20\pi$ radian
Using the equation of motion for circular motion

$$\theta_1 = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$20\pi = \frac{1}{2}\alpha\times3^2 \qquad \{\because \omega_o = 0\}$$

$$20\pi = \frac{9\alpha}{2}$$

$$\alpha = \frac{40\pi}{9}\text{rad/sec}^2$$

Now, Angular velocity at the end of 3sec
$\omega_1 = \omega_0 + \alpha t$

$$= 0 + \frac{40\pi}{9}\times3 = \frac{40\pi}{3}\text{rad/sec}$$

If θ_2 represents the angular displacement from (3 sec) to (6 sec) then-

$$\theta_2 = \omega_1 t + \frac{1}{2}\alpha t^2$$

$$\theta_2 = \frac{40\pi}{3}\times3 + \frac{1}{2}\times\frac{40\pi}{9}\times9 = 40\pi + 20\pi$$

$$\theta_2 = 60\pi$$

$$\text{Number of rotations } = \frac{60\pi}{2\pi} = 30$$

So, the number of rotations is 30

222. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.00 rad/s. In a time of 2 s it has rotated through an angle (in radian) of

(a) 6 (b) 10
(c) 12 (d) 4

JIPMER-2009

Ans. (b) : Given,
Angular acceleration (α) = 3 rad /s^2
Initial angular speed ω_0 = 2rad/s
time (t) = 2s
θ = ?
Applying the equation of the angular displacement-

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$= 2\times2 + \frac{1}{2}\times3\times2^2 = 4 + 6. = 10\text{ rad.}$$

223. A wheel has a speed of 1200 rev/min and is made to slow down at a rate of 4 rads^{-2}. The number of revolutions it makes before coming to rest is

(a) 143 (b) 272
(c) 314 (d) 722

EAMCET-2000

Ans. (c) : Given, Initial frequency (N) = 1200 rpm

$$= \frac{1200}{60} = 20\text{r.p.s}$$

Angular acceleration (α) = –4 rad/s^2
Now, Initial angular velocity, $\omega_i = 2\pi N = 2\pi\times20$
$= 40\pi$ rad/s
Final angular velocity, $\omega_f = 0$
Since, we know that,

$$\omega_f^2 - \omega_i^2 = 2\alpha s$$

$$0 - (40\pi)^2 = 2(-4)\text{ s}$$

$$s = 200\pi^2\text{ rad}$$

$$\therefore \text{No. of revolution, } N' = \frac{200\pi^2}{2\pi}$$

$$N' = 100\pi \approx 314$$

224. Identify the increasing order of the angular velocities of the following

1. Earth rotating about its own axis
2. Hour's hand of a clock
3. Second's hand of a clock
4. Flywheel or radius 2 m making 300 rpm

(a) 1, 2, 3, 4 (b) 2, 3, 4, 1
(c) 3, 4, 1, 2 (d) 4, 1, 2, 3

EAMCET-2005

Ans. (a) : Since, we know
1. Time period of earth's rotation = 24 hrs
= 86400 sec
2. Time period of Hour's hand of clock = 12 hrs
= 43200 sec
3. Time period of second hand of clock = 1 min
= 60sec

@apna_pdf

4. Time period of fly wheel $= \frac{2\pi}{\omega}$

$$= \frac{2\pi}{\frac{2\pi\times300}{60}} = \frac{1}{5}\text{sec.} \qquad \text{(N = 300 rpm given)}$$

$\therefore$ Increasing under of angular velocities is 1 > 2 > 3 > 4.

225. The rope of a kite is wound around a hollow cylinder of mass 200 g and radius 5 cm. If the kite experiences a pull of F = 1 N, what will be the linear acceleration of the rope?

(a) $5\ m/s^2$ (b) $10\ m/s^2$

(c) $15\ m/s^2$ (d) None of these

Assam CEE-2016

Ans. (a) : Given,

Mass of cylinder, M = 200 g = 0.2 kg,

Applied force, F = 1 N

Radius, r = 5 cm = 0.05 m

Moment of inertia (I) = Mr^2

$I = 0.2 \times (0.05)^2$

$I = 5 \times 10^{-4}$ kg-m^2

Torque, $\tau = r \times F$

$\tau = 1 \times 0.05$ N-m

$\tau = 5 \times 10^{-2}$ N-m

For angular acceleration, moment of inertia and torque is also given by the relation,

$\tau = I\,\alpha$

$\therefore \qquad \alpha = \frac{\tau}{I}$

$$\alpha = \frac{5\times10^{-2}}{5\times10^{-4}} = 10^2\ \text{rad/sec}^2$$

α = 100 rad/sec^2

Now,

Linear acceleration,

$a = \alpha.r$

$a = 100 \times 0.05$

a = 5 m/sec^2

226. A wheel which is initially at rest is subjected to a constant angular acceleration about its axis. It rotates through an angle of 15° in time t sec. The increase in angle through which it rotates in the next 2t sec is

(a) 90° (b) 120°

(c) 30° (d) 45°

AP EAMCET -2014

Ans. (b) : We know that,

Initial angular velocity of wheel, $\omega_i = 0$

Angle rotated by wheel in t second, $\theta_1 = 15^\circ$

Let the angular acceleration = α

If Angular acceleration is constant,

$$\theta_1 = \omega_i t + \frac{1}{2}\alpha t^2$$

$$15^\circ = 0 + \frac{1}{2}\alpha t^2$$

$$\alpha t^2 = 30^\circ \qquad \text{.....(i)}$$

Let, angle rotated by wheel in t' second = θ_2

Where,

$t' = t + 2t = 3t$

Now, $\theta_2 = \omega_i t' + \frac{1}{2}\alpha(t')^2$

$$\theta_2 = 0 + \frac{1}{2}\alpha(3t)^2$$

$$\theta_2 = 0 + \frac{9}{2}\alpha t^2$$

$$\theta_2 = \frac{9}{2}\times30^\circ \qquad [\because \alpha t^2 = 30^\circ \text{ from (i)}]$$

$\theta_2 = 135^\circ$

Increase in angle,

$\Delta\theta = \theta_2 - \theta_1$

$\Delta\theta = 135^\circ - 15^\circ = 120^\circ$

227. The angular acceleration α of a spinning top as a function of t is : $\alpha = 3t^2 + 5t$. At t = 0, the angular velocity ω_0 =10 rad/s and angular position θ_0 = 8 rad. The angular position as a function of time t is given by which of the following expression?

(a) $\frac{1}{4}t^4 + \frac{5}{6}t^3 + 10t + 8$

(b) $\frac{5}{6}t^4 + \frac{1}{4}t^3 + \frac{2}{5}t + 8$

(c) $2t^4 + 3t^3 + 5t + 8$

(d) $\frac{1}{4}t^4 + \frac{3}{5}t^3 + 6t^2 + 8$

AMU-2007

Ans. (a) : Given, $\alpha = 3t^2 + 5t$

$$\alpha = \frac{d^2\theta}{dt^2} = 3t^2 + 5t$$

Integrate both sides w.r.t. ‘t’, we get-

$$\frac{d\theta}{dt} = t^3 + \frac{5t^2}{2} + C_1 \qquad (C_1 = \text{constant})$$

$$\omega = \frac{d\theta}{dt} = t^3 + \frac{5t^2}{2} + C_1$$

Using initial conditions, t = 0, ω_0 = 10 rad/s

Then, 10 = C_1

$$\frac{d\theta}{dt} = t^3 + \frac{5t^2}{2} + 10 \qquad \text{....(ii)}$$

Integrate both sides w.r.t. ‘t’, we get-

$$\theta = \frac{t^4}{4} + \frac{5t^3}{6} + 10t + C_2 \qquad (C_2 = \text{constant})$$

Using conditions, at t = 0, θ_0 = 8 rad.

$\therefore \qquad C_2 = 8$

or $\qquad \theta = \frac{t^4}{4} + \frac{5t^3}{6} + 10t + 8$

@apna_pdf

228. **Two racing cars of masses m1 and m2 are moving in circles of radii r1 and r2 respectively. Their speeds are such that each makes a complete circle in the same time t. The ratio of the angular speeds of the first to the second car is**

(a) $r_1 : r_2$ (b) $m_1 : m_2$
(c) 1 : 1 (d) $m_1m_2 : r_1r_2$

AMU-2015

Ans. (c) : We know that, angular speed (ω) = $2\pi n = \frac{2\pi}{T}$

According to the question -

$$T_1 = T_2$$
$$\omega_1 = \omega_2$$
$$\frac{\omega_1}{\omega_2} = 1 \Rightarrow \omega_1 : \omega_2 = 1 : 1$$

229. **Find the linear velocity of a point on a rigid body rotating with angular velocity $\vec{\omega} = 3\hat{i} - 4\hat{j} + \hat{k}$, the radius vector of the point is $\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$,**

(a) $-18\hat{i} - 13\hat{j} + 2\hat{k}$ (b) $18\hat{i} + 3\hat{j} - 2\hat{k}$
(c) $3\hat{i} - 18\hat{j} + 2\hat{k}$ (d) $-3\hat{i} - 18\hat{j} + 2\hat{k}$

AMU-2014

Ans. (a) : Given, $\vec{\omega} = 3\hat{i} - 4\hat{j} + \hat{k}$, $\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$

We know that, $\vec{v} = \vec{\omega} \times \vec{r}$

$$\vec{v} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -4 & 1 \\ 5 & -6 & 6 \end{vmatrix}$$

$$\vec{v} = \hat{i}(-24+6) - \hat{j}(18-5) + \hat{k}(-18+20)$$

$$\vec{v} = -18\hat{i} - 13\hat{j} + 2\hat{k}$$

230. **The angular velocity of a particle rotating in a circular orbit 100 times per minute is**

(a) 10.47 radian/sec (b) 10.0 degree/sec
(c) 40.32 radian/sec (d) 20.57 radian/sec

AMU-2003

Ans. (a) : Given, n = 100 times per min $= \frac{100}{60}$ times per sec

So, angular velocity of particles (ω) = 2πn

$$= 2\pi\frac{100}{60} = \frac{10}{3}\pi$$
$$\omega = 10.47 \text{ rad/sec}$$

231. **If a flywheel makes 120 rev/min, then its angular speed will be**

(a) 8π rad/s (b) 6π rad/s
(c) 4π rad/s (d) 2π rad/s

AIPMT- 1996

Ans. (c) : Given, n = 120 rev/min $= \frac{120}{60} = 2$ rev/sec

Then, angular speed $(\omega) = 2\pi n$

$$= 2\pi \times 2 = 4\pi \text{ rad/sec}$$

232. **A wheel has angular acceleration of 3 rad/ s^2 and an initial angular speed of 2 rad/s. In a time of 2 s, it has rotated through an angle (in radian) of**

(a) 6 (b) 10
(c) 12 (d) 4

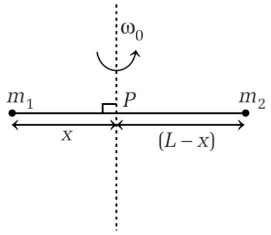
AIPMT- 2007

Ans. (b) : Given, α = 3 rad/sec^2, ω_0 = 2 rad/sec, t = 2 sec

We know that, $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$$\theta = 2 \times 2 + \frac{1}{2} \times 3(2)^2 = 4 + 6$$
$$\theta = 10 \text{ rad}$$

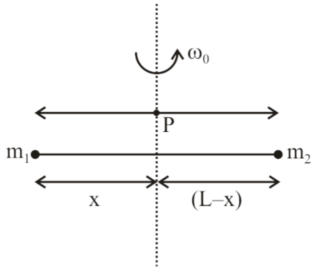
233. **Point masses m_1 and m_2 are placed at the opposite ends of a rigid rod of length L and negligible mass. The rod is to be set rotating about an axis perpendicular to it. The position of point P on this rod through which the axis should pass, so that the work required to set the rod rotating with angular velocity ω_0 is minimum, is given by**



(a) $x = \frac{m_1L}{m_1+m_2}$ (b) $x = \frac{m_1}{m_2}L$
(c) $x = \frac{m_2}{m_1}L$ (d) $x = \frac{m_2L}{m_1+m_2}$

AIPMT- 2015

Ans. (d) : Work required to set the rod rotating with angular velocity (ω_0) is minimum then point P should be at its center of mass.



So,
$$m_1x = m_2(L-x)$$
$$m_1x = m_2L - m_2x$$
$$m_2L = (m_1+m_2)x$$
$$x = \frac{m_2L}{m_1+m_2}$$

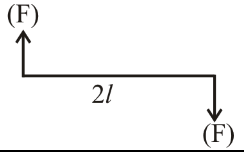
@apna_pdf

234. A couple produces

(a) no motion
(b) linear and rotational motion
(c) purely rotational motion
(d) purely linear motion

AIPMT-1997

Ans. (c) : When two equal force are acting are a body and produces rotational motion of body then it called couple.



235. A disc is rotating with angular velocity ω. If a child sits on it, what is conserved ?

(a) Linear momentum
(b) Angular momentum
(c) Kinetic energy
(d) Moment of inertia

AIPMT-2002

Ans. (b) : A disc is rotating with angular velocity (ω) and child is sits on it, then no any external torque is acting.
So, angular momentum is conserved.

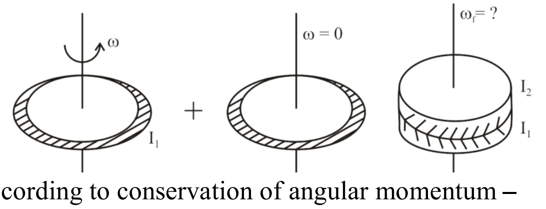
236. A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is

(a) $\frac{I_2\omega}{I_1+I_2}$ (b) ω

(c) $\frac{I_1\omega}{I_1+I_2}$ (d) $\frac{(I_1+I_2)\omega}{I_1}$

AIPMT-2004

Ans. (c) : In this condition,



According to conservation of angular momentum –

$$I_1\omega + 0 = (I_1+I_2)\omega_f$$

$$\omega_f = \frac{I_1\omega}{I_1+I_2}$$

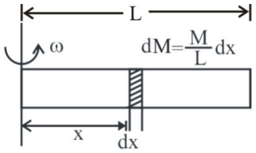
237. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is

(a) $\frac{ML\omega^2}{2}$ (b) $\frac{ML^2\omega}{2}$

(c) $ML\omega^2$ (d) $\frac{ML^2\omega^2}{2}$

AIPMT-2006

Ans. (a) : Let small mass element (dM) at a distance x from the axis of rotation.
Force on this mass element



$$dF = (dM)\omega^2 x = \left(\frac{M}{L}\right)\omega^2 \times x \times dx$$

Total force, is calculated by integration method

$$F = \int_0^L \frac{M}{L}\omega^2 x\,dx = \frac{M}{L}\omega^2\int_0^L x\,dx = \frac{M\omega^2L^2}{2L}$$

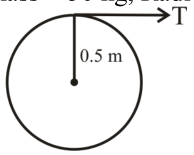
$$F = \frac{ML\omega^2}{2}$$

238. A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about the horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2rev/s^2 is

(a) 25 N (b) 50 N
(c) 78.5 N (d) 157 N

AIPMT- 2014

Ans. (d) : Given, mass = 50 kg, Radius = 0.5m.



Angular acceleration is $\alpha = 2\text{ rev s}^{-2} = 2\times 2\pi\text{ rad s}^{-2}$
$= 4\pi\text{ rad s}^{-2}$
Toque $\tau = I\alpha = TR$
Moment of Inertia of solid cylinder

$$I = \frac{MR^2}{2}$$

$$T = \frac{I\alpha}{R} = \frac{1}{2}\frac{MR^2}{R}\times 4\pi$$

$$= \frac{1}{2}MR\times 4\pi = \frac{1}{2}\times 50\times\frac{1}{2}\times 4\times 3.14$$

T = 157 N

239. A gramophone record is revolving with an angular velocity ω. A coin is placed at a distance r from the centre of the record. The static coefficient of friction is μ. The coin will revolve with the record if

(a) $r = \mu g\omega^2$ (b) $r < \frac{\omega^2}{\mu g}$

@apna_pdf

(c) $r \leq \frac{\mu g}{\omega^2}$ (d) $r \geq \frac{\mu g}{\omega^2}$

AIPMT- 2010

Ans. (c): The coin skid from the record when the centrifugal force need to keep the coin exceeds the frictional force.

That is $\mu_s mg \geq mr\omega^2$

f_s (static friction) is $\leq \mu_s mg$

$$r \leq \frac{\mu_s g}{\omega^2}$$

Option, 'c' is correct.

240. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is a approximately

(a) 7.0 (b) 6.0

(c) 3.0 (d) 8.0

NEET- 2016

Ans. (d): Given, radius = 50 cm = 0.5 meter

Angular acceleration = 2 rad/sec^2

Time = 2 sec

Step 1 :

Tangential acceleration, $a_T = r\alpha$

$= 0.5 \times 2 = 1$ m/sec^2

Step 2 :

Angular velocity

$\omega = \omega_0 + \alpha t$

$\omega = 0 + 2 \times 2$

$\omega = 4$ rad/sec

Radid acceleration $(a_r) = \frac{v^2}{r} = r\omega^2$

$$a_r = \frac{1}{2} \times (4)^2 = 8 \text{m/sec}^2$$

$$a_{Net} = \sqrt{a_r^2 + a_t^2} = \sqrt{8^2 + 1^2} = \sqrt{65}$$

$a_{Net} \approx 8$

241. The angular velocity of a rickshaw wheel is 70 rads^{-1}. If the radius of the wheel is 0.5 m, the linear velocity is

(a) 10 ms^{-1} (b) 1 ms^{-1}

(c) 35 ms^{-1} (d) 70 ms^{-1}

EAMCET-1996

Ans. (c) : Given,

$\omega = 70$ rad/sec^{-1}

r = 0.5 m = 1/2 m

We know that,

$v = r\omega = 1/2 \times 70 = 35$ m/sec

v = 35 m/sec

So, option (c) is correct.

242. A fan is making 600 rev/min. If it makes 1200 rev/min, what is the increase in its angular velocity?

(a) 10 π rad/s (b) 20 π rad/s

(c) 60 π rad/s (d) 40 π rad/s

EAMCET-1996

Ans. (b): Given,

$f_i = 600$ rev/min = 10 rev/sec

$f_f = 1200$ rev/min = 20 rev /sec

$\Delta f = 10$ rev/sec

So, $\Delta\omega = 2\pi\Delta f$

$\Delta\omega = 2\pi \times 10$

$\Delta\omega = 20\pi$ rad/sec

243. The angular velocity of the second's-hand of a watch is

(a) 0.053 rads^{-1} (b) 0.210 rads^{-1}

(c) 0.105 rads^{-1} (d) 0.42 rads^{-1}

EAMCET-1997

Ans. (c): Angular velocity = $2\pi f = 2\pi/T$

For second hand ⇒ time period (T) = 60 sec

$$\omega = \frac{2\pi}{60} = \frac{\pi}{30} = 0.105 \text{rad/sec}$$

$\omega =$ 0.105 rad/sec.

244. At a given instant of time the position vector of a particle moving in a circle with a velocity $3\hat{i} - 4\hat{j} + 5\hat{k}$ is $\hat{i} + 9\hat{j} - 8\hat{k}$. Its angular velocity at that time is

(a) $\frac{(13\hat{i} + 29\hat{j} + 31\hat{k})}{\sqrt{146}}$ (b) $\frac{(13\hat{i} - 29\hat{j} - 31\hat{k})}{146}$

(c) $\frac{(13\hat{i} + 29\hat{j} - 31\hat{k})}{\sqrt{146}}$ (d) $\frac{(13\hat{i} + 29\hat{j} + 31\hat{k})}{146}$

EAMCET-2005

Ans. (b) : Given,

$$\vec{v} = 3\hat{i} - 4\hat{j} + 5\hat{k}$$

$$\vec{r} = \hat{i} + 9\hat{j} - 8\hat{k}$$

$$|\vec{r} \times \vec{v}| = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & +9 & -8 \\ 3 & -4 & 5 \end{vmatrix}$$

$$= \hat{i}(45 - 32) - \hat{j}(5 + 24) + \hat{k}(-4 - 27)$$

$$= 13\hat{i} - 29\hat{j} - 31\hat{k}$$

Angular velocity

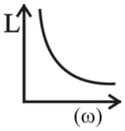
$$\vec{\omega} = \frac{\vec{r} \times \vec{v}}{r^2}$$

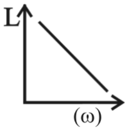
$$\vec{\omega} = \frac{13\hat{i} - 29\hat{j} - 31\hat{k}}{\left(\sqrt{1^2 + 9^2 + 8^2}\right)^2} = \frac{13\hat{i} - 29\hat{j} - 31\hat{k}}{\left(\sqrt{146}\right)^2}$$

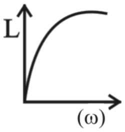
$$\vec{\omega} = \frac{13\hat{i} - 29\hat{j} - 31\hat{k}}{146}$$

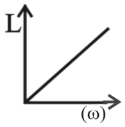
@apna_pdf

245. The graph between the angular momentum E and angular velocity will be.

(a) 

(b) 

(c) 

(d) 

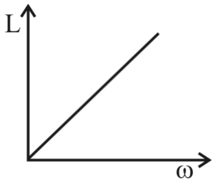
AP EMCET(Medical)-2011

Ans. (d) : We know,

Angular momentum (L) = Iω

Then,

$L \propto \omega$



Hence, the graph between the angular velocity and angular momentum will be straight line.

246. A coin is placed on a rotating turn table slips if it is placed at a minimum distance of 9 cm from the centre. If the angular velocity of the turn table is tripled, it will just slip if the distance from the centre is:

(a) 9 cm
(b) 3 cm
(c) 1.5 cm
(d) 1 cm

AP EAMCET(Medical)-1998

Ans. (d) : Given,

$\omega_1 = \omega$

$\omega_2 = 3\omega$

$r_1 = 9$ cm

$r_2 = ?$

We know that the coin before slipping from the table overcomes the force of static which acts as centripetal force on coin to move in a circular motion.

Then,

$F = m\omega^2 r$

So,

$$m\omega_1^2 r_1 = m\omega_2^2 r_2$$

$$\frac{\omega_1^2}{\omega_2^2} = \frac{r_2}{r_1}$$

Putting the values,

$$\frac{\omega^2}{9\omega^2} = \frac{r_2}{9}$$

Hence, $r_2 = 1$ cm

247. A thin uniform rod AB of mass m and length *l* is hinged at one end A to the level floor. Initially it stands vertically and is allowed to fall freely to the floor in the vertical plane. The angular velocity of the rod, when its end B strikes the floor is (g is acceleration due to gravity):

(a) $\left(\frac{mg}{l}\right)$
(b) $\left(\frac{mg}{3l}\right)^{1/2}$
(c) $\left(\frac{g}{l}\right)$
(d) $\left(\frac{3g}{l}\right)^{1/2}$

AP EAMCET(Medical)-1999

Ans. (d) : Given,

Mass of Rod = m

Length of Rod = l

We know that,

When rod stands vertically,

Initial Potential Energy (P.E) = mgh

Where g = Acceleration due to gravity

h = Height at which center of mass of uniform rod lies

So, $(P.E.)_i = mg\left(\frac{l}{2}\right)$

Initial Kinetic Energy $(K.E.)_i = \frac{1}{2}I\omega^2$

Where ω = Angular velocity of rod = 0

$(K.E.)_i = 0$

When rod touches the ground,

Final Potential Energy $(P.E.)_f = 0$

Final Kinetic Energy $(K.E)_f = \frac{1}{2}I\omega^2$

Where I = Moment of Inertia = $\frac{1}{3}ml^2$

$$(K.E)_f = \frac{1}{2}\times\frac{1}{3}\times ml^2\times\omega^2$$

$$(K.E.)_f = \frac{1}{6}ml^2\omega^2$$

Using the law of conservation of energy,

$$P.E_i + K.E_i = P.E_f + K.E_f$$

$$mg\left(\frac{l}{2}\right) + 0 = 0 + \frac{1}{6}ml^2\omega^2$$

$$g = \frac{l\omega^2}{3}$$

$$\omega^2 = \frac{3g}{l}$$

$$\therefore \quad \omega = \sqrt{\frac{3g}{l}}$$

248. A thin metal disc of radius 0.25 m and mass 2 kg starts from rest and rolls down an inclined plane. If its rotational kinetic energy is 4 j at the foot of the inclined plane, then its linear velocity at the same point is:

(a) 1.2m/s
(b) $2\sqrt{2}$ m/s
(c) 20 m/s
(d) 2 m/s

AP EAMCET(Medical)-1997

Ans. (b) : Given,

Mass of metal disc (m) = 2 kg

Radius of metal disc (r) = 0.25 m

Rotational kinetic Energy (K.E.) = 4 J

@apna_pdf

We know that,

Rotational Kinetic Energy (K.E) = $\frac{1}{2}$ Iω^2

Where I = Moment of Inertia = $\frac{1}{2}$mr^2

ω = Angular velocity = $\frac{v}{r}$

$$K.E. = \frac{1}{2}\times\frac{1}{2}mr^2\times\left(\frac{v}{r}\right)^2$$

$$K.E. = \frac{1}{4}mv^2 \qquad \ldots(i)$$

$$v^2 = \frac{4\times4}{2} \qquad \left[\because \begin{matrix} K.E. = 4J \\ \& \quad m = 2kg \end{matrix}\right]$$

$$\therefore \quad v = 2\sqrt{2}\text{ m/s}$$

249. The angular velocity of the seconds hand in a watch is:

(a) 0.053 rad/s (b) 0.210 rad/s
(c) 0.105 rad/s (d) 0.42 rad/s

AP EAMCET(Medical)-1997

Ans. (c) : Given,
Angle covered by second hand in a watch to complete one cycle (θ) = 2π radian
Time taken to complete one cycle (t) = 60 s
We know,

Angular velocity (ω) = $\frac{\theta}{t}$

$$\omega = \frac{2\pi}{60}$$

$$\omega = \frac{\pi}{30}$$

Hence, ω = 0.1046 rad/s □ 0.105 rad/s

250. A man is sitting on a rotating stool with his arms outstretched. If suddenly he folds his arm the angular velocity of the man would:

(a) increase (b) decrease
(c) become zero (d) remain constant

NDA (II) 2010

Ans. : (a) We know that,
Angular momentum (L) = Iω
When a person is folds his arm on a rotating stool then momentum of inertia (I) decrease and to conserve the angular momentum (L) the angular velocity (ω) increases.

251. If the length of the Equator is about 40000 km and the velocity of rotation is about 1700 km per hour, what would be the velocity of rotation at the pole?

(a) Zero (b) 850 km/hr
(c) 1700 km/hr (d) 3400 km/hr

NDA (II) 2014

Ans. (a) : Given that,
Length of the equator = 40000 km [diameter of earth]
So, r = 20000 km
Velocity of rotation at equator = 1700 km/h

We know that,

v = rω sinθ

Where,

v = Linear velocity
r = Radius of the earth
ω = Angular velocity
θ = Angle between pole and any point where linear velocity is measured

We also know that at poles, the surface of planet does not move but it only rotate about its own axis.
So, θ = 0° or 180° when it is an angle between the poles and θ = 90° when it is an angle between the pole and equator.
For poles, the velocity of rotation at the pole is zero (0).

252. When a ceiling fan is switched off, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest ?

(a) 24 (b) 36
(c) 18 (d) 12

MHT-CET 2008

Ans. (d) : Given that,
n = 36
By using equation,

$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$\left(\frac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha(2\pi n) \qquad (\because \omega = \frac{\omega_0}{2} \ \& \ \theta = 2\pi n)$$

$$\frac{\omega_0^2}{4} = \omega_0^2 - 4\alpha\pi n$$

$$4\alpha\pi n = \omega_0^2 - \frac{\omega_0^2}{4}$$

$$4\alpha\pi n = \frac{3\omega_0^2}{4}$$

$$\alpha = \frac{3\omega_0^2}{4\times4\pi\times36} \qquad \ldots(i) \ (\because n = 36)$$

Again using equation,

$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$0 = \omega_0^2 - 2\alpha(2\pi n') \qquad (\because \omega = 0)$$

$$\omega_0^2 = 4\alpha\pi n' \qquad \ldots(ii)$$

Put the value of α from equation (i) in equation (ii), we get–

$$\omega_0^2 = 4\times\frac{3\omega_0^2}{4\times4\pi\times36}\times\pi n'$$

$$1 = \frac{3n'}{4\times36}$$

$$n' = \frac{4\times36}{3}$$

n' = 48 revolution
Number of more rotation = n' – n
= 48 – 36 = 12

@apna_pdf

253. When a disc is rotating with angular velocity ω, a particle situated at a distance of 4 cm just begins to slip. If the angular velocity is doubled, at what distance will the particle start to slip?

(a) 1 cm (b) 2 cm (c) 3 cm (d) 4 cm

MHT-CET 2010

Ans. (a) : Angular velocity = ω

Centripetal force, $F = mr\omega^2$

$$F = r_1\omega_1^2 = r_2\omega_2^2$$

Thus, $\frac{r_2}{r_1} = \frac{\omega_1^2}{\omega_2^2}$, $r_2 = \frac{\omega_1^2}{\omega_2^2} r_1$

$$r_2 = \left(\frac{1}{2}\right)^2 \times 4, \quad r_2 = \frac{1}{4} \times 4$$

∴ $r_2 = 1$ cm

254. A wheel has a speed of 1200 revolutions per minute and is made to slow down at a rate of 4 rad s^{-2}. The number of revolutions it makes before coming to rest is:

(a) 143 (b) 272

(c) 314 (d) 722

MHT-CET 2010

Ans. (c) : Rotation, N = 1200 r.p.m

Retardation, $\alpha = 4$ rad/s^2

∴ Initial angular velocity, $\omega_i = \frac{2\pi N}{60}$ rad/s

∴ $\omega_i = \frac{2\pi \times 1200}{60} = 40\pi$

Let angle rotated before coming to rest be θ,

$$\omega_f^2 = \omega_i^2 - 2\alpha\theta$$

$$\theta = \frac{\omega_i^2 - \omega_f^2}{2\alpha} = \frac{(40\pi)^2}{2\alpha} = \frac{1600\pi^2}{2\times 4} \quad [\because \omega_f = 0]$$

$\theta = 200\pi^2$ rad.

Angle rotated in 1 revolution = 2π

So, total number of revolution, $n = \frac{\theta}{2\pi}$

$$n = \frac{200\pi^2}{2\pi} = 100\pi$$

$n = 100 \times 3.14$

$n = 314$

255. A flywheel at rest is to reach an angular velocity of 24 rad/s in 8 second with constant angular acceleration. The total angle turned through during this interval is

(a) 24 rad (b) 48 rad

(c) 72 rad (d) 96 rad

MHT-CET 2016

Ans. (d) : Given,

Initial angular velocity, $\omega_o = 0$ rad/s

Angular velocity, $\omega = 24$ rad/s

Time, t = 8s

∵ $\omega = \omega_o + \alpha t$

∴ $\alpha = \frac{\omega - \omega_o}{t}$

$$\alpha = \frac{24-0}{8}$$

Angular acceleration, $\alpha = 3$ rad/s^2

Now, angular displacement

$$\theta = \omega_o t + \frac{1}{2}\alpha t^2$$

$$\theta = 0\times 8 + \frac{1}{2}\times 3\times (8)^2 = 0 + \frac{1}{2}\times 3\times 64$$

∴ θ = 96 rad.

256. The angular speed of an engine wheel making 90 rev/min is

(a) 1.5π rad/s (b) 3π rad/s

(c) 4.5π rad/s (d) 6π rad/s

AIPMT- 1995

Ans. (b) : Given,

Angular frequency (n) = 90 rev/min,

$$n = \frac{90}{60}\text{rev/s} = \frac{3}{2}\text{rev/s}$$

We know that,

Angular speed (ω) = 2πn

$$\omega = 2\pi \times \frac{3}{2}, \quad \omega = 3\pi \text{ rad/s}$$

257. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.0 rad/s. In a time of 2s it has rotated through an angle (in radian) of

(a) 6 (b) 10 (c) 12 (d) 4

UPSEE - 2007

Ans. (b) : Given:

Angular acceleration, α = 3rad/sec^2

Initial angular speed, ω_0 = 2 rad/sec

t = 2 sec

Now, Angular displacement,

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = 2\times 2 + \frac{1}{2}\times 3\times 2^2 = 2\times 2 + 12/2 = 4 + 6$$

θ = 10 radians.

258. A ceiling fan rotates about its own axis with some angular velocity. When the fan is switched off, the angular velocity becomes $\left(\frac{1}{4}\right)^{th}$ of the original in time 't' and 'n' revolutions are made in that time. The number of revolutions made by the fan during the time interval between switch off and rest are (Angular retardation is uniform)

(a) $\frac{4n}{15}$ (b) $\frac{8n}{15}$ (c) $\frac{16n}{15}$ (d) $\frac{32n}{15}$

MHT-CET 2016

Ans. (c) : Angular velocity after switched off $(\omega') = \frac{\omega}{4}$

α = – α (Due to retardation)

∵ $\omega'^2 = \omega_0^2 - 2\alpha Q$

$$\left(\frac{\omega}{4}\right)^2 = \omega^2 - 2\alpha(2\pi n) \quad \{\because Q = 2\pi n\}$$

$$\frac{\omega^2}{16} = \omega^2 - 2\alpha n(2\pi)$$

@apna_pdf

$$\frac{15}{16}\omega^2 = 2\alpha n(2\pi)$$

$$2\pi n = \frac{15}{16}\frac{\omega^2}{2\alpha} \qquad \ldots\ldots(i)$$

Let the fan made n' revolution during interval between switch off and rest

$$\because \quad \omega'^2 = \omega_0^2 - 2\alpha Q$$

$$0 = \omega^2 - 2\alpha(2\pi n')$$

$$\frac{\omega^2}{2\alpha} = 2\pi n' \qquad \ldots..(ii)$$

Dividing equation (i) from (ii), we get-

$$n' = \frac{16}{15}n$$

259. A wheel of moment of inertia 2Kg-m^2 is rotating about an axis passing through centre and perpendicular to its plane at a speed 60 rad/s. Due to friction, it comes to rest in 5 minutes. The angular momentum of the wheel three minutes before it stops rotating is

(a) 24 Kg m^2/s (b) 48 Kg m^2/s
(c) 72 Kg m^2/s (d) 96 Kg m^2/s

MHT-CET 2016

Ans. (c) : Given

I = 2 kg m^2, ω_0 = 60 rad /s

t = 5 min = 5×60 = 300 sec

$\omega' = 0$

$\because \omega' = \omega_0 + \alpha t$

$0 = 60 + \alpha(300)$

$$\alpha = \frac{-60}{300} = \frac{-1}{5}\text{rad/sec}^2$$

Angular moment before three minutes to stop means after 2 min from starting.

$\because \omega = \omega_0 + \alpha t$

$$\omega = 60 + \left(-\frac{1}{5}\right)\times 120 \qquad [\because 2\,\text{min} = 120\,\text{sec}]$$

$$\omega = 60 - 24 = 36\,\text{rad/s}$$

Now, angular momentum, L= Iω

L = 2×36

L = 72 kg-m^2/sec

260. If the body is moving in a circle of radius r with a constant speed v. Its angular velocity is

(a) v^2/r (b) vr (c) v/r (d) r/v

MHT-CET 2011

Ans. (c) : Given that,

Radius of circle = r,

Speed = v

Linear velocity, v = rω

$$\omega = \frac{v}{r}$$

Where, ω = Angular velocity

Hence, angular velocity of body is $\frac{v}{r}$

261. If α is angular acceleration, ω is angular velocity and a is the centripetal acceleration then, which of the following is true ?

(a) $\alpha = \frac{\omega a}{v}$ (b) $\alpha = \frac{v}{\omega a}$

(c) $\alpha = \frac{av}{\omega}$ (d) $\alpha = \frac{a}{\omega v}$

MHT-CET 2010

Ans. (a) : Given,

Angular acceleration = α

Angular velocity = ω

Centripetal acceleration = a

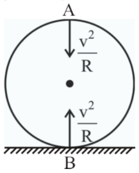
We know,

Angular acceleration, $\alpha = \frac{\omega}{t}$

$$\alpha = \frac{\omega v}{vt}$$

$$\therefore \quad \alpha = \frac{\omega a}{v} \qquad \left[\because a = \frac{v}{t}\right]$$

262. A wheel of radius R rolls on the ground with a uniform velocity v. The relative acceleration of topmost point of the wheel with respect to the bottom most point is



(a) $\frac{v^2}{R}$ (b) $\frac{2v^2}{R}$ (c) $\frac{v^2}{2R}$ (d) $\frac{4v^2}{R}$

BITSAT-2012

Ans. (b) : Centripetal acceleration towards the centre,

$$a_A = \frac{v^2}{R}(\text{downward})$$

$$a_B = \frac{-v^2}{R}(\text{upward})$$

$\therefore$ Relative acceleration,

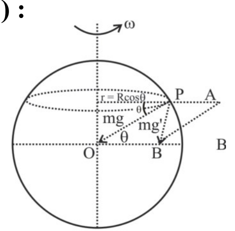
$$a_{AB} = a_A - a_B = \frac{v^2}{R} - \left(\frac{-v^2}{R}\right) = \frac{2v^2}{R}$$

263. If the speed of the rotation of earth increases, then the weight of the body at the equator is .

(a) increases
(b) decreases
(c) remains unchanged
(d) may increase or decrease

AMU-2002

Ans. (b) :



$$mg' = mg - mr\omega^2$$

$$g' = g - r\omega^2$$

Where, ω = Angular speed of earth

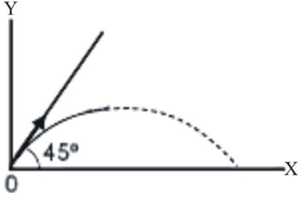
Greater the ω, less the value of g'

Hence weight of body decreases if ω increases.

@apna_pdf

(c) Torque, Angular Momentum

264. A particle of mass 100 g is projected at time t = 0 with a speed 20 ms^{-1} at an angle 45° to the horizontal as given in the figure. The magnitude of the angular momentum of the particle about the starting point at time t = 2s is found to be $\sqrt{K}$ kg m^2/s. The value of K is______.(Take g = 10 ms^{-2})



JEE Main-29.01.2023, Shift-II

Ans. (800) : Given,
Mass of particle (m) = 100g = 0.1 kg
Velocity of particle (v) = 20 ms^{-1}
Time (t) = 2sec
Angle of projection = 45°
$\because$ $v_x = v\sin 45° = 10\sqrt{2}$ ms^{-1}
We know that, Angular momentum

$$L_0 = \int_0^t \tau\, dt$$

$$L_0 = \int_0^2 mg(v \times t)dt$$

$$L_0 = mg\, v_x \frac{t^2}{2} = (0.1)\times(10)\times 10\sqrt{2}\times\frac{2^2}{2}$$

$$L_0 = 20\sqrt{2} = \sqrt{K}$$

$$\sqrt{K} = \sqrt{800}\,\text{kg m}^2/\text{s}$$

$\therefore$ K = 800 kg m^2/s

265. A thin circular ring of mass M and radius r is rotating about its axis with an angular velocity ω. Two objects, each of mass m, are attached gently to the opposite ends of a diameter of the ring. The ring now rotates with an angular velocity

(a) ωM/(M +m)
(b) ωM/(M+2m)
(c) ω(M–2m)/M+2m)
(d) ω(M+2m)/M

AMU-2017
AIPMT-2009, 1998, AIEEE-2006, 2002
MHT CET-2003, Punjab PMT-2002
BHU-1998, CG PET- 2004

Ans. (b) : Initial mass of ring = M kg,
Initial angular velocity = ω
Let final angular velocity = ω'
Final mass of the ring = (M + 2m) kg
Law of conservation of angular moment

$$I_1\omega_1 = I_2\omega_2$$

$$Mr^2\omega = (M+2m)r^2\times\omega'$$

$$\omega' = \frac{M\omega}{M+2m}$$

266. A constant torque acting on a uniform circular wheel changes its angular momentum from A_0 to 4 A_0 in 4s. The magnitude of this torque is

(a) $\frac{3A_0}{4}$
(b) A_0
(c) $4A_0$
(d) $121A_0$

BCECE-2013, CG PET- 2007
JIPMER-2005, Manipal UGET-2010
BHU-2005, 1998, AIIMS-1997
MP PMT-1987

Ans. (a) : Given that,
$L_2 = 4A_0$
$L_1 = A_0$
$\Delta t = 4$ sec
Change in angular momentum
$\Delta L = L_2 - L_1$
$\Delta L = 4A_0 - A_0$
$\Delta L = 3A_0$

$$\text{Torque }(\tau) = \frac{\Delta L}{\Delta t}$$

$$\tau = \frac{3A_0}{4}$$

267. A wheel having moment of inertia 2kg-m^2 about its vertical axis, rotates at the rate of 60 rpm about this axis. The torque which can stop the wheel's rotation in one minute would be

(a) $\frac{2\pi}{13}$ N – m
(b) $\frac{\pi}{14}$ N – m
(c) $\frac{\pi}{15}$ N – m
(d) $\frac{\pi}{20}$ N – m

AIIMS-26.05.2019 (M), Shift-I
JCECE-2014
UP CPMT-2013
AIPMT-2004
Kerala PMT-2004

Ans. (c) : Given that,
I = 2 kgm^2
N = 60 rpm
t = 60 sec

$$\omega = \frac{2\pi N}{60} = \frac{2\pi\times 60}{60}$$

$\omega = 2\pi$
Torque required to stop the wheel's rotation is–

$$\tau = I\cdot\alpha = I\left(\frac{\omega}{t}\right)$$

$$= 2\times\frac{2\pi}{60}$$

$$\tau = \frac{\pi}{15}\,\text{N} - \text{m}$$

268. A particle of mass m is moving with a constant velocity along a line parallel to the positive direction of x-axis. The magnitude of its angular momentum with respect to the origin

(a) is zero
(b) goes on increasing as x increases

@apna_pdf

(c) goes on decreasing as x increase

(d) remains constant for all positions of the particle

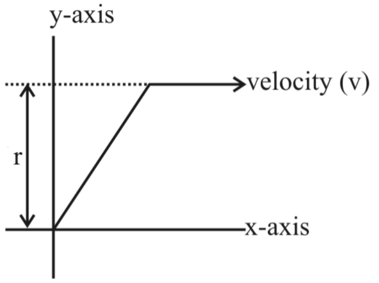
AMU-2018, 2009, 2004

RPET-2000

IIT-1997, 1985

MP PET-1997, 1996

Ans. (d) : A particle of mass m is moving with constant velocity and it is parallel to the x-axis.



We know that,

Angular momentum ($\vec{L}$) = $\vec{p}\times\vec{r}$

Where, r = perpendicular distance

p = linear momentum, L is angular momentum

From figure, perpendicular distance and velocity are perpendicular to each other. Now, velocity, mass and distance (r) all are constant. So, we can say that angular momentum will be constant.

269. If force $\vec{F}=3\hat{i}+4\hat{j}-2\hat{k}$ acts on a particle having position vector $2\hat{i}+\hat{j}+2\hat{k}$ then, the torque about the origin will be :

(a) $3\hat{i}+4\hat{j}-2\hat{k}$

(b) $-10\hat{i}+10\hat{j}+5\hat{k}$

(c) $10\hat{i}+5\hat{j}-10\hat{k}$

(d) $10\hat{i}+\hat{j}-5\hat{k}$

JEE Main-25.06.2022, Shift-I

AP EAMCET - 29/08/2021 (Shift-I)

NEET (Sept.) - 2020

AI PMT - 1997

Ans. (b) : Given,

$$\vec{F}=3\hat{i}+4\hat{j}-2\hat{k}$$

$$\vec{r}=2\hat{i}+\hat{j}+2\hat{k}$$

We know that,

Torque $(\vec{\tau})=\vec{r}\times\vec{F}$

$$\vec{\tau}=\left(2\hat{i}+\hat{j}+2\hat{k}\right)\times\left(3\hat{i}+4\hat{j}-2\hat{k}\right)$$

$$\vec{\tau}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 2 & 1 & 2\\ 3 & 4 & -2\end{vmatrix}$$

$$\vec{\tau}=\hat{i}(-2-8)-\hat{j}(-4-6)+\hat{k}(8-3)$$

$$\vec{\tau}=-10\hat{i}+10\hat{j}+5\hat{k}$$

270. A mass m is moving with a constant velocity along a line parallel to x-axis. Its angular momentum with respect to origin on z-axis is

(a) Zero

(b) Remain constant

(c) Goes on increasing

(d) Goes on decreasing

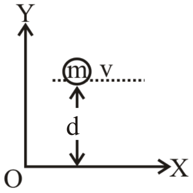
BITSAT-2013, 2007

CG PET- 2012

Ans. (b) : As we know that

Angular momentum of particle with respect to origin = Linear momentum × Perpendicular distance on line of action of linear momentum from origin

$$= mv \times d = mvd = \text{Constant}$$



271. A constant torque of 1000 N-m turns a wheel of moment of inertia 200 kg-m^2 about an axis through its centre. Its angular velocity after 3 second is, in rad/s:

(a) 1

(b) 5

(c) 15

(d) 10

AIPMT-2001

CPMT-1999

AP EAMCET(Medical)-1997

Ans. (c) : Given,

Torque $(\tau)=1000\,\text{N}-\text{m}$

Moment of Inertia (I) = 200 kg m^2

Time (t) = 3 sec

We know that,

$$\tau = I\,\alpha$$

$$1000 = 200 \times \alpha$$

$$\alpha = 5\,\text{rad/sec}^2$$

From equation of motion,

$$\omega = \omega_0 + \alpha t$$

$$\omega = 0 + 5 \times 3$$

$$\omega = 15\ \text{rad/sec}$$

272. The angular momentum of a particle with respect to the origin will not be zero, if

(a) the directional line of linear momentum passes through the origin

(b) the particle is at the origin

(c) the angle between the position vector and linear momentum is 180°

(d) the linear momentum vanishes

(e) the angle between the position vector and linear momentum is 90°

Kerala CEE 04.07.2022

Ans. (e) : We know that,

angular momentum, $L=\vec{r}\times\vec{p}=rp\sin\theta$

The conditions in which the value of angular momentum is zero, are given below.

➡ @apna_pdf

(1) When the directional line of liner momentum passes through the origin it means the value of θ will be zero so that sin θ = 0.

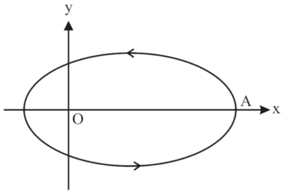
Hence angular momentum (L) will be zero

(2) When the value of position vector is zero, it means the particle is at the origin.

(3) When the value of θ will be 180°, it means the angle between the position vector and linear momentum is 180°.

(4) When the value of linear momentum will be zero, it means the linear momentum vanishes.

273.



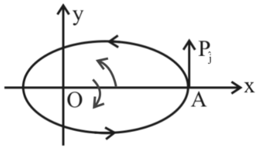
A particle is moving in an elliptical orbit as shown in figure. If $\vec{p}, \vec{L}$ and $\vec{r}$ denote the linear momentum, angular momentum and position vector of the particle (from focus O) respectively at a point at A, then the direction of $\vec{\alpha} = \vec{p} \times \vec{L}$ is along.

(a) +ve x axis (b) –ve x axis

(c) +ve y axis (d) –ve y axis

WB JEE 2022

Ans. (a) :



From figure,

Linear momentum is moving anti-clockwise direction and perpendicular to radius from point A towards +ve y-axis ($p\hat{j}$).

From right hand thumb Rule,

Angular momentum ($\vec{L}$) is towards +ve z-axis $\left(L\hat{k}\right)$

Now,

$$\vec{\alpha} = \vec{p} \times \vec{L}$$

$$\vec{\alpha} = (p\,\hat{j}) \times (L\,\hat{k})$$

$$= pL\left(\hat{j} \times \hat{k}\right)$$

$$= pL\,\hat{i}$$

From properties of cross product of 2 vector, therefore the direction of α is +ve x-axis.

274. If the radius of a spherical object, rotating about its diameter with a time period of 2 second, is reduced to half its actual value, keeping its mass unchanged, its time period becomes _____ (assuming zero external torque)

(a) Remains the same (b) 6 s

(c) 0.5 s (d) 1 s

AP EAMCET-03.09.2021, Shift-I

Ans. (c)

Initial angular momentum of spherical object

$$L_1 = I\omega = \frac{2}{5}MR^2\omega$$

Final angular momentum of Spherical object

$$L_2 = I\omega = \frac{2}{5}M\left(\frac{R}{2}\right)^2 \omega'$$

∵ External torque is zero (Given)

So, Momentum will be conserved-

$$L_1 = L_2$$

$$\frac{2}{5}MR^2\omega = \frac{2}{5}M\left(\frac{R}{2}\right)^2 \omega'$$

$$\omega R^2 = \frac{R^2}{4}\omega'$$

$$\Rightarrow \quad \frac{1}{T} = \frac{1}{4T'}$$

$$\frac{1}{2} = \frac{1}{4T'} \qquad (T = 2\,\text{sec.})$$

$$T' = \frac{1}{2}\text{sec.}$$

$$T' = 0.5\,\text{sec}$$

275. A wheel of mass 20 kg and radius 30 cm is rotating at an angular speed of 80 rev/min when the motor is turned off. Neglecting the friction at the axis, calculate the force that must applied tangentially to the wheel to bring it to rest in 5 revolution.

(a) 1.06 πN (b) 2.06 πN

(c) 3.06 πN (d) 4.06 πN

TS EAMCET 06.08.2021, Shift-I

Ans. (a) : Given, mass of the wheel (m)= 20 kg, radius (R) = 30 cm = 0.3 m

Rotational Speed (ω_1) = $\frac{80}{60} = \frac{4}{3}\text{rev/sec}$

$\omega_2 = 0$

Total revolution (N) = 5 rev

We know that, $\omega_2^2 = \omega_1^2 - 2\alpha N$

$$0 = \left(\frac{4}{3}\right)^2 - 2 \times \alpha \times 5$$

Now, $\alpha = \frac{8}{45}\text{rev/sec}^2$

$$\alpha = \frac{8}{45} \times 2\pi = \frac{16}{45}\pi \text{ rad/sec}^2 \qquad (\because 1\text{ Rev} = 2\pi\,\text{rad})$$

Moment of inertia (I) = $\frac{1}{2}mR^2$

$$I = \frac{1}{2} \times 20 \times (0.3)^2 = 0.9\,\text{kgm}^2$$

Therefore, Torque = F.R = I α

$$0.3 \times F = 0.9 \times \frac{16}{45}\pi$$

$$F = 1.06\pi\text{ N}$$

@apna_pdf

276. A uniform disc of radius 'a' and mass 'm' is rotating freely with an angular speed of 'ω' in a horizontal plane about a smooth fixed vertical axis passing through its center. A particle, also of mass 'm' is suddenly attached to the rim of the disc and starts to rotate with it. The new angular speed of this system is ________

(a) $\frac{\omega}{3}$ (b) $\frac{\omega}{6}$

(c) $\frac{\omega}{2}$ (d) $\frac{\omega}{5}$

AP EAMCET-25.08.2021, Shift-I

Ans. (a) : Moment of inertia of the disc, $I_1 = \frac{1}{2}ma^2$

Final moment of inertia, $I_2 = \frac{1}{2}ma^2 + ma^2 = \frac{3}{2}ma^2$

By law of conservation of angular momentum –

$$I_1\,\omega_1 = I_2\,\omega_2$$

$$\frac{1}{2}ma^2\ \omega = \frac{3}{2}ma^2 \times \omega_2 \qquad (\because\ \omega_1 = \omega)$$

$$\omega_2 = \frac{\omega}{3}$$

277. Assertion (A): Angular speed, linear speed as Kinetic energy change with time but angular momentum remains constant for a planet orbiting the sun.

Reason (R): Angular momentum is constant as no torque acts on the planet.

(a) Both A and R are true and R is a correct explanation for A

(b) Both A and R are true but R is not a correct explanation for A

(c) A is true. R is false

(d) A is false. R is true

AP EAMCET-23.08.2021, Shift-I

Ans. (a) : We know that,

Net torque acting at on the rotating planet is zero.

Then,

$$\tau = 0$$

We know that,

$$\text{Torque } (\tau) = \frac{dL}{dt}$$

$$\frac{dL}{dt} = 0 \qquad [\therefore\ \tau = 0]$$

Hence,

L = constant

We also know,

Angular momentum (L) = mvr

Where,

L = constant

vr = constant

From above equation, we can say that the distance between sun and planet changes. Its kinetic energy also changes.

We also know,

Angular momentum (L) = $mr^2\omega$

Where,

L = constant

$r^2\omega$ = constant

So, as the distance between sun and planet changes, angular speed of the planet changes.

Hence, both A and R are true but R is correct explanation of A.

278. A thin rod of mass 'm' and length '2l' is made to rotate about an axis passing through its centre and perpendicular to it. Its angular velocity changes from 0 to ω in time 't'. What is the torque acting on the rod?

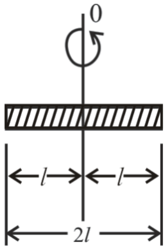
(a) $\frac{ml^2\omega}{12t}$ (b) $\frac{ml^2\omega}{t}$

(c) $\frac{ml^2\omega}{3t}$ (d) $\frac{4ml^2\omega}{3t}$

AP EAMCET-24.08.2021, Shift-I

Ans. (c) : Given that, mass = m, Length = 2l

$$\text{Inertia of rod}(I) = \frac{mL^2}{12} \qquad (\text{Here}, L = 2l)$$



Also, from equation of angular motion

$$\omega_f = \omega_0 + \alpha t$$

$$\omega = 0 + \alpha t$$

$$\alpha = \frac{\omega}{t} \qquad \text{....(i)}$$

Torque = Iα {where α = angular acceleration}

$$= \frac{m(2l)^2}{12}.\frac{\omega}{t} = \frac{m4l^2}{12} \times \frac{\omega}{t}$$

$$\text{Torque} = \frac{ml^2\omega}{3t}$$

279. A constant torque acting on a uniform circular wheel changes its angular momentum from 1A$_0$ to 5A$_0$ to in 6 seconds, Then the magnitude of torque is ——

(a) $\frac{2}{3}A_0$ (b) $\frac{3}{4}A_0$

(c) 4 A_0 (d) 12 A_0

AP EAMCET-06.09.2021, Shift-I

Ans. (a) : Torque is rate of change of angular momentum $= \frac{5A_0 - 1A_0}{6} = \frac{4A_0}{6} = \frac{2}{3}A_0$

@apna_pdf

280. Two flywheels A and B are mounted side by side with frictionless bearings on a common shaft. Their moments of inertia about the shaft are 5.0kg-m^2 and 20.0kg-m^2 respectively. Wheel A is made to rotate at 10 revolution per second. Wheel B, initially stationary, is now coupled to A with the help of a clutch. The rotation speed of the wheels will become

(a) $2\sqrt{5}$ rps (b) 0.5 rps

(c) 2 rps (d) 3 rps

AP EAMCET-20.08.2021, Shift-II

Ans. (c) : Given that,

$I_A = 5$ kg m^2, $I_B = 20$ kg m^2, n = 10 rev/sec,

$\omega_B = 0$, $\omega_A = 2\pi n = 2\pi\times 10 = 20\pi$

From conservation of angular momentum,

$I_A\omega_A + I_B\omega_B = (I_A+I_B)\omega$

$I_A(20\pi) + I_B \times 0 = (5+20)\omega$

$5\times 20\pi = 25\omega$

$\Rightarrow \omega = 4\pi \quad \Rightarrow 2\pi n = 4\pi$

$\Rightarrow \quad n = 2$ rps

281. A circular hoop of radius 50 cm and mass 1 kg rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. Let 'v' be the velocity of the centre of the hoop when it ceases to slip. The ratio v/ω_0 will be:

(a) 10 cm (b) 50 cm

(c) 25 cm (d) 12.5 cm

TS EAMCET 05.08.2021, Shift-II

Ans. (c) : Given, radius (r) = 50 cm, mass (m) = 1 kg

Angular velocity = ω_0

From conservation of angular momentum

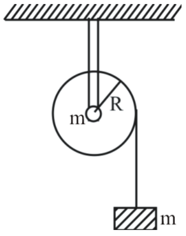
$$mr^2\omega_0 = mvr + mr^2\frac{v}{r} = 2mvr$$

$$1 \times (50)^2 \times \omega_0 = 2 \times 1 \times v \times 50$$

$$\frac{v}{\omega_0} = \frac{2500}{100}$$

$$\frac{v}{\omega_0} = 25\text{cm}$$

282. A mass m is supported by a massless string wound around a uniform cylinder of mass m and radius R. On releasing the mass from rest, it will fall with acceleration

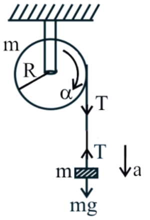


(a) g (b) $\frac{g}{2}$

(c) $\frac{2g}{3}$ (d) $\frac{3g}{2}$

AP EAMCET (22.09.2020) Shift-II

Ans. (b) :



From, Free body diagram we have,

mg – T = ma ....(i)

Now,

$$\tau_{net} = I\alpha$$

$$R \times T = mR^2.\frac{a}{R} \qquad \{\because I = mR^2\}$$

$$T = ma \qquad ....(ii)$$

Now, from eq^n (i) and (ii), we have,

$$mg - ma = ma$$

$$2a = g$$

$$a = \frac{g}{2}$$

283. A same torque is applied to a disc and a ring of equal mass and radii then

(a) both will rotate with same angular acceleration.

(b) the ring will rotate with greater angular acceleration.

(c) both will rotate with same angular velocity.

(d) the disc will rotate with greater angular frequency.

MHT-CET 2020

Ans. (d) : A same torque is applied to a disc and a ring of equal mass and radius then the disc will rotate with greater angular frequency.

$\because$ Angular acceleration (α) = $\frac{\tau}{I}$

So,

$$\alpha_{disc} = \frac{\tau}{\frac{MR^2}{2}} = \frac{2\tau}{MR^2}$$

$$\alpha_{ring} = \frac{\tau}{MR^2}$$

Then, $\alpha_{disc} > \alpha_{ring}$

$\because \alpha = \frac{\Delta\omega}{\Delta t}$

$\Rightarrow \omega_{disc} > \omega_{ring}$

284. If there is a change of angular momentum from 1 J-s to 4 J-s in 4 second, then the torque is-

(a) $\left(\frac{3}{4}\right)$J (b) 1 J

(c) $\left(\frac{4}{3}\right)$J (d) $\left(\frac{5}{4}\right)$J

MHT-CET 2020

@apna_pdf

Ans. (a) : Given, angular momentum $(L_1) = 1$ J-s , $L_2 =$ 4J-s, $\Delta t = 4$ sec

We know that, Torque $(\tau) = \dfrac{\Delta L}{\Delta t} = \dfrac{L_2 - L_1}{\Delta t} = \dfrac{4-1}{4}$

$$\tau = \frac{3}{4}\text{J}$$

285. A solid sphere of radius r is revolving about one of its diameters with an angular velocity ω. If it suddenly expands uniformly so that its radius increases to n times its original value, then its angular velocity becomes

(a) $n^2\omega$ (b) $\dfrac{\omega}{n^2}$

(c) $n\omega$ (d) $\dfrac{\omega}{n}$

(e) $2n\omega$

Kerala CEE 2020

Ans. (b) Given,

Radius of solid sphere = r

Angular velocity = ω

Here, there is no external torque acting on the system

So, angular momentum of the system will remain constant

$$I_1 = \frac{2}{5}Mr^2$$

After radius in increases to n times it original value, then $I_2 = \dfrac{2}{5}M\left(nr^2\right)$

According to law of conservation of angular momentum

$$I_1\omega_1 = I_2\omega_2$$

$$\frac{2}{5}Mr^2 \times \omega_1 = \frac{2}{5}Mn^2r^2 \times \omega_2$$

$$\omega_1 = n^2\ \omega_2$$

$$\omega_2 = \frac{\omega_1}{n^2}$$

Hence, angular velocity becomes $\dfrac{\omega}{n^2}$

286. When the torque acting on a system is zero, which of the following remains constant?

(a) linear momentum (b) angular momentum

(c) linear impulse (d) linear velocity

AP EAMCET-25.09.2020, Shift-I, II

Ans. (b) : When no external torque acting on the system then angular momentum of a system of particle remains constant.

$$\frac{dL}{dt} = \tau$$

$\because \quad \tau = 0$

$$\frac{dL}{dt} = 0$$

$\therefore \quad L = \text{constant}$

Hence, Total angular momentum of the system is remains constant.

287. The moment of inertia of a flywheel making 300 revolutions per minute is 0.3 kg m^2. Find the torque required to bring it to rest in 20 seconds.

(a) 47.1 N.m (b) –47.1 N.m

(c) –0.471 N.m (d) 0.471 N.m

AP EAMCET-24.09.2020, Shift-II

Ans. (c) : Given,

Moment of Inertia (I) = 0.3 kg m^2

Time (t) = 20 s

Rotation per minute = 300 rpm

$$f = \frac{300}{60} = 5 \text{ Rotation per sec}$$

$$\omega_0 = 2\pi f = 2\pi \times 5 = 10\pi \text{ rad/sec}$$

We know that,

$$\omega = \omega_0 + \alpha t$$

$$\omega = \omega_0 - \alpha t \qquad \begin{bmatrix}\text{In condition of} \\ \text{deceleration}\end{bmatrix}$$

Where, final angular acceleration $(\omega) = 0$

$$\omega_0 = \alpha t$$

$$10\pi = \alpha \times 20$$

$$\alpha = \frac{10\pi}{20} = \frac{\pi}{2}$$

Torque $(\tau) = I\alpha = 0.3 \times \dfrac{\pi}{2} = 0.15\pi$

$$= 0.15 \times 3.14$$

$$\tau = 0.471\text{Nm}$$

Torque is opposes the motion of fly wheel.

So, most correct answer is (c).

$$\tau = -0.471\text{Nm}$$

288. A force of $\left(7\hat{i} + 3\hat{j} - 5\hat{k}\right)$N acts on a particle whose position vector is $\left(\hat{i} - \hat{j} + \hat{k}\right)$m. Find the torque experienced by the particle about the origin in N-m.

(a) $2\hat{i} + 12\hat{j} + 10\hat{k}$ (b) $3\hat{i} + 10\hat{j} + 12\hat{k}$

(c) $10\hat{i} + 12\hat{j} + 2\hat{k}$ (d) $12\hat{i} + 10\hat{j} + 2\hat{k}$

TS EAMCET 29.09.2020, Shift-II

Ans. (a) : Force, F = $\left(7\hat{i} + 3\hat{j} - 5\hat{k}\right)$N

Distance, r = $\left(\hat{i} - \hat{j} + \hat{k}\right)$m

Torque will be

$$\vec{\tau} = \vec{F} \times \vec{r}$$

$$\tau = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & +1 \\ 7 & 3 & -5 \end{vmatrix}$$

$$= \hat{i}(5-3) - \hat{j}(-5-7) + \hat{k}(3+7)$$

$$= 2\hat{i} + 12\hat{j} + 10\hat{k}$$

@apna_pdf

289. Effect of a couple is

(a) purely linear motion
(b) purely rotational motion
(c) linear and rotational motion
(d) no motion

AP EAMCET (22.09.2020) Shift-I

Ans. (b) : A couple mainly comprises of two parallel forces which are both equal in magnitude but opposite in direction.

There is no line of action along which both forces act and hence it produces only rotational motion.

290. A constant torque of 200 N-m turns a flywheel, which is at rest, about an axis through its centre and perpendicular to its plane. If its moment of inertia is 50 kg-m^2, then in 4 second, what will be change in its angular momentum?

(a) 200 kg-m^2/s
(b) 800 kg-m^2/s
(c) 20 kg-m^2/s
(d) 40 kg-m^2/s

MHT-CET 2020

Ans. (b) : Given,

$\tau = 200$ N m,
$t = 4$ sec,
$I = 50$ kg m^2

We know,

Change in angular momentum = Torque × time

$$= \tau \times t = 200 \times 4$$
$$= 800 \text{ kg m}^2/\text{s}$$

291. A disc of moment of inertia 'I_1' is rotating with angular velocity 'ω_1' about an axis perpendicular to its plane, passing through its centre. If another disc of moment of inertia 'I_2' about the same axis is gently placed over it, then the new angular velocity of the combined disc will be

(a) $\frac{(I_1+I_2)\omega_1}{I_1}$
(b) $\frac{I_2\omega_1}{I_1+I_2}$
(c) $\frac{I_1\omega_1}{I_1+I_2}$
(d) ω_1

MHT-CET 2020

Ans. (c) : We know,

Total initial angular momentum,

$$L_i = I_1\,\omega_1 + I_2(0) = I_1\omega_1$$

Total final angular momentum,

$$L_f = (I_1+I_2)\omega_2$$

By law of conservation of angular momentum,

$$I_1\,\omega_1 = (I_1+I_2)\omega_2$$
$$\omega_2 = \frac{I_1\,\omega_1}{I_1+I_2}$$

292. Force $\vec{F}$ is acting on a particle having position vector $\vec{r}$. Let $\vec{\tau}$ be the torque of this force about the origin. The correct equation is

(a) $\vec{r}.\vec{\tau} \neq 0$ and $\vec{F}.\vec{\tau} = 0$
(b) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} = 0$
(c) $\vec{r}.\vec{\tau} \neq 0$ and $\vec{F}.\vec{\tau} \neq 0$
(d) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} \neq 0$

MHT-CET 2020

Ans. (b) : We know,

Torque $(\vec{\tau}) = \vec{r} \times \vec{F}$

Angle between $\vec{\tau}$ and $\vec{F}$ = 90°
Angle between $\vec{\tau}$ and $\vec{r}$ = 90°

Now, we take dot product,

At $\theta = 90°$
$\cos 90° = 0$

Hence, $\vec{r}.\vec{\tau} = 0$
$\vec{F}.\vec{\tau} = 0$

293. A torque of 50 Nm acts on a body for 8 second which is initially at rest. The change in its angular momentum is

(a) 400 kgm^2/s
(b) 800 kgm^2/s
(c) 1000 kgm^2/s
(d) 600 kgm^2/s

MHT-CET 2020

Ans. (a): Given,

$\tau = 50$ N-m
$t = 8$ sec
$\vec{L} = ?$

We know,

$$\text{Torque}(\tau) = \frac{dL}{dt}$$
$$dL = \tau \times dt$$
$$\vec{L} = 50 \times 8$$
$$= 400 \text{ kgm}^2/\text{sec}$$

294. A 20kg flywheel in the form of a uniform circular disc, 1m in diameter is making 120 rpm. What is its angular momentum?

(a) 3.14 kg m^2 S^{-1}
(b) 31.4 kg m^2 S^{-1}
(c) 314 kg m^2 S^{-1}
(d) 0.314 kg m^2 S^{-1}

AP EAMCET (22.09.2020) Shift-II
EAM CET-2002

Ans. (b) : Given,

Mass of flywheel, (m) = 20 kg
N = 120 rpm

∵ Diameter of circular disc (d) = 1m

∴ Radius (R) = $\frac{\text{Diameter}}{2}$

$$R = \frac{1}{2}$$
$$R = 0.5 \text{ m}$$

Angular velocity,

$$\omega = \frac{2\pi N}{60}$$
$$\omega = \frac{2\pi \times 120}{60}$$
$$\omega = 4\pi \text{ rad/sec}$$

Moment of inertia of uniform circular disc,

$$I = \frac{mR^2}{2}$$
$$I = \frac{20 \times (0.5)^2}{2}$$

@apna_pdf

$I = 2.5\ \text{kg m}^2$

Now, angular momentum,

$L = I\omega$

$L = 2.5 \times 4\pi$

$L = 31.4\ \text{kg m}^2\ \text{S}^{-1}$

295. A ballet dancer suddenly folds her outstretched arms. Her angular velocity

(a) Increases
(b) Decreases
(c) Remains the same
(d) May increase or decrease

AP EAMCET (18.09.2020) Shift-I

Ans. (a) : According to law of conservation of angular momentum.

$I\omega$ = Constant

$$\therefore\ \omega \propto \frac{1}{I} = \frac{1}{MR^2} \Rightarrow \omega \propto \frac{1}{R^2}$$

I = Moment of inertia

ω = Angular velocity

When a ballet dancer suddenly folds her outstretched arms, her angular velocity will increases and her moment of inertia decreases.

296. A disc of moment of inertia I_1 is rotating with an angular velocity ω_1. Another disc of moment of inertia I_2 which is not rotating, is gently put on the first disc. The angular speed of the system will be

(a) $\left(\frac{I_1 + I_2}{I_1}\right)\omega_1$
(b) $\left(\frac{I_1}{I_1 + I_2}\right)\omega_1$
(c) $\left(\frac{I_1 - I_2}{I_1}\right)\omega_1$
(d) $\left(\frac{I_1}{I_1 - I_2}\right)\omega_1$

AP EAMCET (17.09.2020) Shift-II

Ans. (b) : According to the law of conservation of angular momentum

$I\omega$ = Constant

When second disc is dropped on it and forms a unit,

$L_1 = L_2$

$I_1\omega_1 = (I_1 + I_2)\omega_2$

$$\omega_2 = \left(\frac{I_1}{I_1 + I_2}\right)\omega_1$$

297. If the torque acting on a rigid body, under the application of a force, is zero then it's

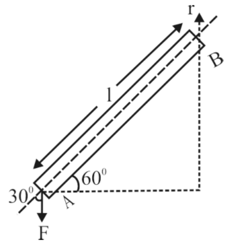
(a) Linear momentum is conserved
(b) Angular momentum is not conserved
(c) Energy is conserved
(d) Angular momentum is conserved

AP EAMCET (22.09.2020) Shift-II
UPSEE - 2011

Ans. (d) : If the torque acting on a rigid body, under the application of a force, is zero then it's angular momentum is conserved.

298. A rod 'ℓ' m long is acted upon by a couple as shown in figure. The moment of couple is 'τ' Nm. If the force at each end of the rod, the magnitude of each force is

$(\sin 30^0 = \cos 60^0 = \frac{1}{2})$



(a) $\frac{\ell}{2\tau}$
(b) $\frac{\tau}{\ell}$
(c) $\frac{2\ell}{\tau}$
(d) $\frac{2\tau}{\ell}$

MHT CET-2019

Ans. (d) : Length of rod = ℓ

Moment of couple,

$\tau = F \times OA$

$$\sin 30° = \frac{OA}{l}$$

$OA = l\sin 30°$

$\tau = F\ell\sin\theta = F\ell\sin 30°$

$$\therefore\quad F = \frac{\tau}{\ell\sin 30°} = \frac{\tau}{\ell \times \frac{1}{2}}$$

$$F = \frac{2\tau}{\ell}$$

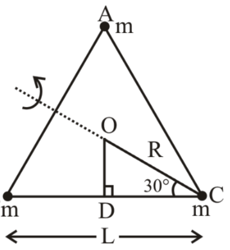
299. Three point masses each of mass 'm' are kept at the corners of an equilateral triangle of side 'L'. The system rotates about the centre of the triangle without any change in the separation of masses during rotation. The period of rotation is directly proportional to (cos 30^0 = sin 60^0 = $\sqrt{3}/2$)

(a) $L^{\frac{3}{2}}$
(b) $\sqrt{L}$
(c) L^2
(d) L

MHT-CET 2019

Ans. (c) : Given, mass of each point = m

Side of triangle = L, T = ?



AB = BC = CA = L

@apna_pdf

In right angle ΔOCD,

$$\cos 30^\circ = \frac{DC}{OC}$$

$$\frac{\sqrt{3}}{2} = \frac{L/2}{R}$$

$$\text{or } R = \frac{L}{\sqrt{3}} \qquad \text{....(i)}$$

As the system is rotating about the center of triangle.

So, moment of inertia (I) = mR^2

Putting the value of R from (i), we get

$$I = m\left(\frac{L}{\sqrt{3}}\right)^2$$

$$I = m\frac{L^2}{3}$$

Thus, $I \propto L^2$ .....(ii)

According to law of conservation of angular momentum

$$L = I\omega = \text{Constant}$$

$$I \times \frac{2\pi}{T} = \text{Constant} \qquad \left(\because \omega = \frac{2\pi}{T}\right)$$

$$I \propto T \qquad \text{....(iii)}$$

From equation (ii) and (iii) we get–

$$T \propto L^2$$

300. An electric motor of power 75 W rotates a flywheel of moment of inertia 0.36kgm^2 at a constant rate of 100 rads^{-1}. If the power is switched off, the time taken for the wheel to come to rest is

(a) 12 s (b) 24 s

(c) 36 s (d) 48 s

AP EAMCET (22.04.2019) Shift-II

Ans. (d) : Given that,

$I = 0.36$ kg-m^2

$\omega_i = 100$ rad/sec

$P = 75$ W

We know,

$$\text{Angular acceleration } (\alpha) = \frac{\omega_f - \omega_i}{t} \qquad \left(\begin{array}{l}\because \alpha = -\alpha \text{ because} \\ \text{fly wheel get retard}\end{array}\right)$$

$$-\alpha = -\frac{\omega_i}{t} \qquad [\because \omega_f = 0]$$

$$t = \frac{\omega_i}{\alpha} \qquad \text{....(i)}$$

As we know that, power of an electric motor (P) = $\tau\omega_i$

Torque, $\tau = I\alpha$ (I = moment of inertia)

$\therefore$ $P = I\alpha\omega_i$

$$\alpha = \frac{P}{I\omega_i} \qquad \text{....(ii)}$$

Putting the value of α in equation (i), we get

$$t = \frac{\omega_i}{(P/I\omega_i)} = \frac{I\omega_i^2}{P}$$

$$t = \frac{0.36 \times (100)^2}{75} = 48 \text{ sec}$$

301. A flywheel of mass 1 kg and radius vector $(2\hat{i} + \hat{j} + 2\hat{k})$ m is at rest. When a force $(3\hat{i} + 2\hat{j} - 4\hat{k})$ N acts on it tangentially, it can rotate freely. Then, its angular velocity after 4.5 s is

(a) $\frac{2}{9}\sqrt{261}$ rad s^{-1} (b) $\frac{3}{2}\sqrt{261}$ rad s^{-1}

(c) $\sqrt{261}$ rad s^{-1} (d) $\frac{5}{9}\sqrt{261}$ rad s^{-1}

AP EAMCET (21.04.2019) Shift-I

Ans. (c) : Given:

M = 1 kg, t = 4.5 sec

$R = (2\hat{i} + \hat{j} + 2\hat{k})$ m

$F = (3\hat{i} + 2\hat{j} - 4\hat{k})$ N

Magnitude of radius

$$R = \sqrt{4+1+4} = \sqrt{9} = 3$$

$$F = \sqrt{9+4+16} = \sqrt{29}$$

Torque on the flywheel,

$$\tau = I\alpha = F.R = \frac{MR^2}{2}\alpha$$

$$\alpha = \frac{2F}{MR} = \frac{2\sqrt{29}}{1 \times 3} = \frac{2}{3}\sqrt{29} \text{ rad/sec}^2$$

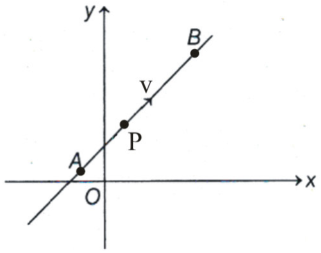
Angular velocity

$$\omega = \omega_0 + \alpha t$$

$$\omega = 0 + \frac{2}{3} \times \sqrt{29} \times 4.5 \qquad [\because \omega_0 = 0]$$

$$\omega = \sqrt{261} \text{ rad/sec}$$

302. A particle P is moving uniformly along a straight line as shown in the figure. During the motion of the particle from A to B, the angular momentum of the particle about O :



(a) Increase

(b) Decrease

(c) Remains constant

(d) First increase then decrease

Karnataka CET-2019

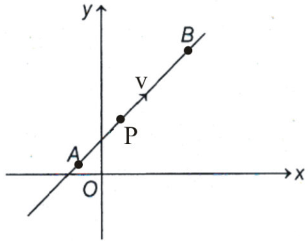
Ans. (c): We know,

Angular momentum (L) = mvr

Where r is the perpendicular distance between the velocity and the reference point.

@apna_pdf

Since, the line AB is straight, there will be only perpendicular distance from the reference point i.e. OA.



So,

Angular momentum at A = mvr
Angular momentum at P = mvr
Angular momentum at B = mvr

Since the perpendicular distance between the line AB and O will always be r.

The angular momentum of all points on the line AB will be equal to mvr.

303. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same. Which one of the following will not be affected?

(a) Angular velocity
(b) Angular momentum
(c) Moment of inertia
(d) Rotational kinetic energy

VITEEE-2019

Ans. (b): The angular momentum of the sphere remains constant because no external torque is acting on the sphere. ω, I and rotational kinetic energy are affected.

304. The distance between Sun and Earth is 1.6 × 10^{11} m and the radius of Earth is 6.4 × 10^6 m. The ratio of the angular momentum of Earth around the Sun to the angular momentum around its own axis is approximately (Assume Earth as a solid sphere with uniform mass density and rotates around the Sun in a circular path.)

(a) 2.0×10^2 (b) 5.1×10^8
(c) 4.3×10^6 (d) 8.7×10^{12}

TS-EAMCET-06.05.2019, Shift-1

Ans. (c) : Mass of earth = M_e

Radius = R_e, Distance = R
Velocity of earth = v_e

So, Angular momentum around sun $L_1 = M_e v_e R$

$$= M_e \times \frac{2\pi R}{T_e} \times R$$

Where T_e = 365 days.

Now, angular momentum about its own axis,

$$L_2 = I\omega$$

$$= \frac{2}{5} M_e R_e^2 \times \omega$$

$$= \frac{2}{5} M_e R_e^2 \frac{2\pi}{T_e} \quad \text{(Here T = 1 day)}$$

$$\text{So, } \frac{L_1}{L_2} = \frac{5R^2}{2\times365\times R_e^2} = \frac{5\times\left(1.6\times10^{11}\right)^2}{2\times365\times\left(6.4\times10^6\right)^2} = 4.3\times10^6$$

305. If a rolling body's angular momentum changes by 20 SI units in 3 seconds, by a constant torque. Then find the torque on the body

(a) 20/3 SI units (b) 100/3 SI units
(c) 20 SI units (d) 5 SI units

BITSAT-2019

Ans. (a) : Given:

dL = 20 units
dt = 3 sec

As we know, τ is change in angular momentum

$$\tau = \frac{dL}{dt}$$

$$\tau = \frac{20}{3} \text{SI units}$$

306. A cyclist rides up a hill with constant velocity. When he exerts an average force of 20 kg-wt on the 50 cm pedal rod. It completes 6 revolutions in 4 s. The power developed by cyclist is

(a) 0.924 kW (b) 3.20 kW
(c) 1032 kW (d) 723.4 kW

AP EAMCET-25.04.2018, Shift-II

Ans. (a) : Given that,

$F = 20\text{kg} - \text{wt} = 20\times9.8 \Rightarrow 196\text{N}, l = 50\text{cm} \Rightarrow 0.5\text{m},$

$t = 4\text{s, for 6 revolutions}$

So, for 1 revolution $t = \frac{4}{6} = \frac{2}{3}\text{sec.}$

Torque produces by the force $\tau = F.l$

$= 196\times0.50 \Rightarrow 98\,\text{N-m}$

$$\because \quad \omega = \frac{2\pi}{T} = \frac{2\times3.14}{2/3} = \frac{2\times3.14\times3}{2}$$

$= 9.42$

Power, $P = \tau.\omega$

$= 98\times9.42$

$= 923.16\text{W}$

$P = 0.924\text{kW}$

307. A billiard ball of diameter 5 cm at rest is hit by a cue at a height 0.5 cm above its centre. If it rolls with a linear velocity of 10 ms^{-1}, then its angular velocity is

(a) 250 rad s^{-1} (b) 400 rad s^{-1}
(c) 200 rad s^{-1} (d) 500 rad s^{-1}

AP EAMCET-25.04.2018, Shift-II

Ans. (c) : Given

Linear velocity v_0 = 10m/s
Height, h = 0.5cm ⇒ 0.005m

Diameter, d = 5cm, radius, r = 2.5cm ⇒ 0.025m

The effort of force F lies at height h,

$$\text{Torque } \tau = I\alpha = I.\frac{\omega}{t}$$

$$F.h = \frac{2}{5}mr^2 \times \frac{\omega}{t} \quad \left[\because I_{\text{sphere}} = \frac{2}{5}mr^2\right]$$

$$ma.h = \frac{2}{5}mr^2\frac{\omega}{t}$$

$$m.\frac{v_o}{t}.h = \frac{2}{5}mr^2\frac{\omega}{t}$$

@apna_pdf

$$v_o h=\frac{2}{5}r^2\omega$$

$$\omega=\frac{5v_o h}{2r^2}$$

By putting the value,

$$\omega=\frac{5\times10\times0.005}{2\times0.025\times0.025}$$

$$\omega=\frac{5\times5\times5\times10^3}{25\times25}=200\text{rad}/\text{s}$$

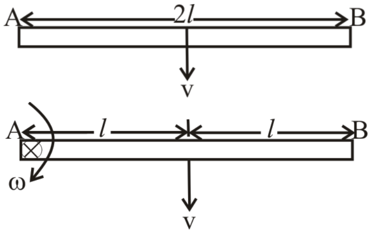
308. A uniform rod AB of mass 'm' and length '2l' is falling freely without rotation under gravity with AB horizontal. Suddenly the end A is fixed when the speed of the rod is 'v'. The angular speed with which the rod begins to rotate is

(a) $\frac{v}{l}$ (b) $\frac{8v}{3l}$

(c) $\frac{2v}{3l}$ (d) $\frac{3v}{2l}$

AP EAMCET-25.04.2018, Shift-II

Ans. (d) :



We know that,

Initial angular momentum, $\vec{L}_i=mvr\Rightarrow(mv)\frac{l}{2}$ …. (i)

Final angular momentum, $\vec{L}_f=\left(\frac{ml^2}{3}\right)\omega$ …..(ii)

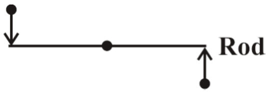
From equation (i) and (ii),

$$\vec{L}_f=\vec{L}_i$$

$$\left(\frac{ml^2}{3}\right)\omega=\frac{mvl}{2}$$

$$\omega=\frac{3v}{2l}$$

309. A rigid uniform rod of mass 'M' and length 'L' is resting on a smooth horizontal table. It is pivoted at its centre. Two marbles each of mass $\frac{M}{6}$ moving with uniform speed L ms^{-1} in the plane of the table collide with the two ends of the rod simultaneously as shown in the figure. The marbles stuck to the rod and continue to move with the rod. Time taken by the rod to rotate through an angle $\frac{\pi}{2}$ radian is (in seconds)

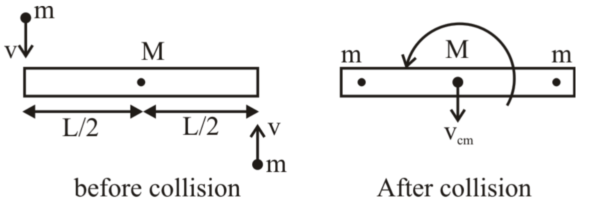


(a) 1 (b) 2π

(c) π (d) $\frac{\pi}{2}$

AP EAMCET-25.04.2018, Shift-I

Ans. (d) :



According to law of conservation of angular momentum

$$I_1\omega_1=I_2\omega_2$$

$$m_1v_1r_1=m_2v_2r_2$$

$$I\omega=m_1v_1r_1+m_1v_1r_1$$

$$\left[\text{Where, }I=\frac{ML^2}{12}+m\left(\frac{L}{2}\right)^2+m\left(\frac{L}{2}\right)^2\right]$$

$$\left[\frac{ML^2}{12}+m\left(\frac{L}{2}\right)^2+m\left(\frac{L}{2}\right)^2\right]\omega=mv\left(\frac{L}{2}\right)+mv\left(\frac{L}{2}\right)$$

$$\left[\frac{6mL^2}{12}+\frac{2mL^2}{4}\right]\omega=mvL\qquad\left(\because\frac{M}{6}=m\right)$$

$$\left[\frac{6mL^2+6mL^2}{12}\right]\omega=mvL$$

$$\omega\left(mL^2\right)=mvL$$

$$\omega L=v\quad[\because v=L]$$

$$\omega=\frac{L}{L}\Rightarrow1$$

$$\omega=1\text{ rad}/\text{sec}.$$

Time period, $T=\frac{\theta}{\omega}$ $\left(\because\theta=\frac{\pi}{2}\right)$

$$=\frac{\pi}{2\times1}$$

$$=\frac{\pi}{2}\text{sec}.$$

310. A solid sphere of radius R makes a perfect rolling down on a plane which is inclined to the horizontal axis at an angle θ. If the radius of gyration is k, then its acceleration is

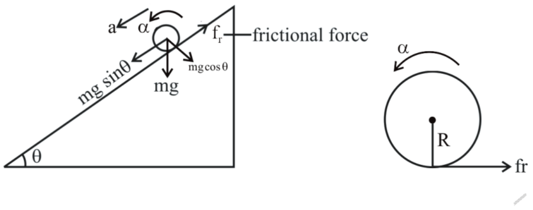
(a) $\frac{g\sin\theta}{\left(1+\frac{k^2}{R^2}\right)}$ (b) $\frac{g\sin\theta}{\left(R^2+k^2\right)}$

(c) $\frac{g\sin\theta}{2\left(R^2+k^2\right)}$ (d) $\frac{g\sin\theta}{2\left(1+\frac{k^2}{R^2}\right)}$

TS-EAMCET-04.05.2018, Shift-1

@apna_pdf

Ans. (a) :



From free body diagram, we have,

$$ma = mg\sin\theta - f_r \quad .....(i)$$

And $\tau = f_r.R = I\alpha$

$$f_r.R = mk^2.\frac{a}{R} \quad \begin{bmatrix}\because a = R.\alpha \\ \& \ I = mk^2\end{bmatrix}$$

$$f_r = \frac{mk^2a}{R^2}$$

Using eq^n. (i),we get

$$ma = mg\sin\theta - \frac{mk^2a}{R^2}$$

$$\left(a + \frac{k^2a}{R^2}\right) = g\sin\theta$$

$$a\left[1+\frac{k^2}{R^2}\right] = g\sin\theta$$

$$a = \frac{g\sin\theta}{\left(1+\frac{k^2}{R^2}\right)}$$

311. The moment of the force, $\vec{F} = 4\hat{i}+5\hat{j}-6\hat{k}$ at (2,0,–3), about the point (2,–2,–2), is given by

(a) $-7\hat{i}-8\hat{j}-4\hat{k}$ (b) $-4\hat{i}-\hat{j}-8\hat{k}$

(c) $-8\hat{i}-4\hat{j}-7\hat{k}$ (d) $-7\hat{i}-4\hat{j}-8\hat{k}$

NEET 2018

Ans. (d) : Given, $\vec{F} = 4\hat{i}+5\hat{j}-6\hat{k}$

$$\vec{r}_A = 2\hat{i}+0\hat{j}-3\hat{k}\ ,\ \vec{r}_B = 2\hat{i}-2\hat{j}-2\hat{k}$$

$$\vec{r} = \vec{r}_{AB} = \left(2\hat{i}+0\hat{j}-3\hat{k}\right)-\left(2\hat{i}-2\hat{j}-2\hat{k}\right)$$

$$= 2\hat{i}-3\hat{k}-2\hat{i}+2\hat{j}+2\hat{k}$$

$$\vec{r} = 2\hat{j}-\hat{k}$$

$$\vec{\tau} = \vec{r}\times\vec{F} = \left(2\hat{j}-\hat{k}\right)\times\left(4\hat{i}+5\hat{j}-6\hat{k}\right)$$

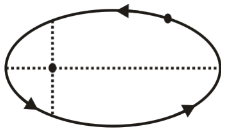
$$\vec{\tau} = \begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 0 & 2 & -1\\ 4 & 5 & -6\end{vmatrix}$$

$$\hat{i}(-12+5)-\hat{j}(0+4)+\hat{k}(0-8)$$

$$\vec{\tau} = -7\hat{i}-4\hat{j}-8\hat{k}$$

Option (d) is correct.

312. The minimum and maximum distance of planet from sun is r_{min} and r_{max}. If velocity at r_{max} is V_0 then find velocity at r_{min}.



(a) $\dfrac{V_0r_{max}}{r_{min}}$ (b) $\dfrac{2V_0r_{min}}{r_{max}}$

(c) $\dfrac{3V_0r_{min}}{r_{max}}$ (d) $\dfrac{2V_0r_{max}}{r_{min}}$

AIIMS-26.05.2018(E)

Ans. (a) : By law of conservation angular momentum,
$mV_0r_{max} = mVr_{min}$

$$V = \frac{V_0r_{max}}{r_{min}}$$

By Kepler's law the areal velocity = $\dfrac{L}{2m}$ (constant)

Hence, L (angular momentum) is constant.

313. A Light rope is wound around a hollow cylinder of mass 4 kg and radius 40 cm. If the rope is pulled with a force of 40 N, its angular acceleration is

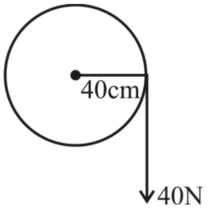
(a) 0.40 rads^{-2} (b) 0.25 rads^{-2}

(c) 25 rads^{-2} (d) 40 rads^{-2}

AP EAMCET (23.04.2018) Shift-1

Ans. (c) : Given, M = 4kg, r = 40 cm = 40/100 m = 0.4 m

F = 40 N



We know that,

$$\tau = I.\alpha$$

$$F.r = Mr^2\alpha$$

$$40\times\frac{40}{100} = 4\times(0.4)^2\times\alpha$$

$$40\times0.4 = 4\times(0.4)^2\,\alpha$$

$$\alpha = 25\ \text{rads}^{-2}$$

314. A thin circular ring of mass m and radius R is rotating about its axis perpendicular to the plane of the ring with a constant angular velocity ω . Two point particles each of mass M are attached gently to the opposite ends of a diameter of the ring. The ring now rotates with an angular velocity ω /2. Then, the ratio m/M is

(a) 1 (b) 2

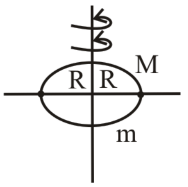
(c) $\dfrac{1}{2}$ (d) $\sqrt{2}$

(e) $\dfrac{1}{\sqrt{2}}$

Kerala CEE -2018

@apna_pdf

Ans. (b) :



$\tau_{external} = 0$

$\therefore$ Angular momentum is conserved.

$L_i = L_f$

$I_{ring}\omega = I_{ring}\omega' + 2MR^2\,\omega'$

$mR^2\omega = mR^2\,\frac{\omega}{2} + 2MR^2\,\frac{\omega}{2}$

$m - \frac{m}{2} = M$

$\frac{m}{2} = M$

$\frac{m}{M} = 2$

315. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere?

(a) Rotational kinetic energy
(b) Moment of inertia
(c) Angular velocity
(d) Angular momentum

NEET- 2018

Ans. (d) : In free space,

$\tau_{external} = 0$

$\frac{dL}{dt} = 0$

L = constant

Taking equal masses sphere, if radius is increased. Then moment of inertia, rotational kinetic energy and angular velocity will change but due to the law of conservation of momentum, angular momentum will not change.

So,

$L_1 = L_2$

316. A rock of mass m is thrown at an angle α with respect to the horizontal. Assume the acceleration due to gravity is g and that the motion of the rock is in the Y-Z plane. The component of the angular momentum at time 't' in the X-direction is.

(a) 0
(b) $\frac{-mv\cos\alpha gt^2}{2}$
(c) mv cos α
(d) $\frac{-mv^3}{2gt}$

TS EAMCET (Medical)-02.05.2018, Shift-I

Ans. (b) : $\vec{M}(t) = \vec{r}\times\vec{p}$

$$= \left(\vec{v}t + \frac{1}{2}gt^2\right)\times m\left(\vec{v} + gt\right)$$

$$= mvgt^2\sin\left(\frac{\pi}{2}+\alpha\right)\left(-\vec{k}\right) + \frac{1}{2}mvgt^2\sin\left(\frac{\pi}{2}+\alpha\right)k$$

$$= \frac{1}{2}mvgt^2\cos\alpha\left(-\vec{k}\right)$$

$$M(t) = \frac{-mvgt^2\cos\alpha}{2}$$

317. Angular momentum is

(a) A scalar
(b) A polar vector
(c) A scalar as well as vector
(d) An axial vector

SRM JEE-2018

Ans. (d) :

Axial vectors are those vectors which represent rotational effect and act along the axis of rotation.

Eg.: Angular velocity, torque, angular momentum etc are Axial vectors.

Angular momentum– Property characterizing the rotary inertia of an object or system of objects in motion about an axis that may or not pass through the object or system.

Formula–

L = mvr, in vector form $\boxed{\vec{L} = \vec{r}\times\vec{p}}$

where –
L = angular momentum.
m = mass
v = velocity
r = radius.
SI Unit – kg. m^2s^{-1}
Dimension – $[ML^2T^{-1}]$

318. Two particles of masses m_1 and m_2 have equal kinetic energies. The ratio of their momentum is:

(a) $m_1 : m_2$
(b) $m_2 : m_1$
(c) $\sqrt{m_1} : \sqrt{m_2}$
(d) $m_1^2 : m_2^2$

Karnataka CET-2018

Ans. (c): We know,

$$\text{Kinetic energies } (\text{K.E.}) = \frac{1}{2}mv^2$$

$$\text{K.E.} = \frac{p^2}{2m}$$

Where m = mass of the particle

For particle (i),

$$(\text{K.E.})_1 = \frac{p_1^2}{2m_1}$$

and for particle (ii),

$$(\text{K.E.})_2 = \frac{p_2^2}{2m_2}$$

@apna_pdf

Given,

$$(K.E.)_1 = (K.E.)_2$$

$$\frac{p_1^2}{2m_1} = \frac{p_2^2}{2m_2}$$

Now,

p_1, p_2 are momentum of particles and m_1 and m_2 are mass of particles respectively.

$$\therefore \quad \vec{p} = 2ql$$

$$\left(\frac{p_1}{p_2}\right)^2 = \left(\frac{m_1}{m_2}\right)$$

$$\frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}}$$

$$p_1 : p_2 = \sqrt{m_1} : \sqrt{m_2}$$

319. Assertion: An ice-skater stretches out arms-legs during performance.

Reason: Stretching out arms-legs helps the performer to balance his or her body so that he or she does not fall.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-27.05.2018(E)

Ans. (c) : An ice-skater stretches out arms and legs during performance to take advantage of principal of conservation of angular momentum. As on doing so, their moment of inertia increases or decreases respectively, hence angular velocity of spin motion decreases or increases accordingly.

320. Assertion: Torque on a body can be zero even if there is a net force on it.

Reason: Torque and force on a body are always perpendicular.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(M)

Ans. (b) : Torque on a body $\tau = \vec{r} \times \vec{F}$

If $\vec{F} = 0$ then $\vec{\tau} = 0$

Hence, assertion is correct

And torque is always perpendicular to radius from vector but it is not reason behind torque to be zero.

321. Assertion: A satellite is orbiting around a planet then its angular momentum is conserved.

Reason: Linear momentum conservation leads to angular momentum conservation.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(E)

Ans. (c) : A satellite is orbiting around a planet then its angular momentum is conserved because force of the planet are always at 180°.

But linear momentum will not be conserved because of continuously force acting on the planet and changing its direction of velocity.

322. If a disc of mass M and radius R rotates with an angular acceleration a, of the torque acting on the disc is

(a) $MR^2 a$ (b) $\frac{MR^2a}{2}$
(c) $\frac{2MR^2a}{5}$ (d) $\frac{MR^2a}{12}$

TS-EAMCET-07.05.2018, Shift-1

Ans. (b) : Torque is given by $\tau = I \times \alpha$

For a disc rotating about an axis, the moment of inertia is given by $I = \frac{1}{2}MR^2$ (Where R = Radius of disc M = mass)

Angular acceleration $\alpha = a$

$$\text{Torque } \tau = I \times a \qquad \left(I \text{ for disk} = \frac{1}{2}MR^2\right)$$

$$\tau = \frac{1}{2}MR^2a$$

$$\boxed{\tau = \frac{MR^2a}{2}}$$

323. A uniform disc of mass 100 kg and radius 2 m is rotating at 1 rad/s about a perpendicular axis passing through its centre. A boy of mass 60 kg standing at the centre of the disk suddenly jumps to a point which is 1 m from the centre of the disc. The final angular velocity of the boy (in rad/s) is

(a) 0.77 (b) 0.5
(c) 41 (d) 2

TS-EAMCET-04.05.2018, Shift-2

Ans. (a): Given,

$M_1 = 100\text{kg}$
$R_1 = 2$ m
$\omega_1 = 1\text{rad/sec}$ $\qquad \omega_2 = ?$
$R_2 = 1$ m

@apna_pdf

Angular momentum is conserved

$$I_1\omega_1 = I_2\omega_2$$

$$\frac{1}{2}M_1R_1^2\times\omega_1=\frac{1}{2}M_2R_2^2\times\omega_2$$

$$\left(\frac{1}{2}\times100\times2^2\right)\times1=\left(\frac{1}{2}\times100\times2^2+60\times1^2\right)\times\omega_2$$

$$\omega_2=\frac{200}{200+60}$$

$$\omega_2=\frac{200}{260}$$

$\omega_2 = 0.77$ rad/sec

324. A force $F_1 = A\hat{j}$ is applied to a point, whose radius vector $r_1 = a\hat{i}$, while a force $F_2 = B\hat{i}$, is applied to the point whose radius vector $r_2 = b\hat{j}$. Both the radius vectors are determined relative to the origin of the coordinate axes *O*. The moment of the force relative to *O* is

(a) $(aA-bB)\hat{k}$ (b) $(aA-bB)\hat{j}$

(c) $(ab-AB)\hat{k}$ (d) $(aB-bA)\hat{j}$

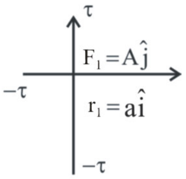
TS-EAMCET-04.05.2018, Shift-2

Ans. (a) : Given that,

$$F_1 = A\hat{j} \qquad r_1 = a\hat{i}$$

$$F_2 = B\hat{i} \qquad r_2 = b\hat{j}$$

Ist case–

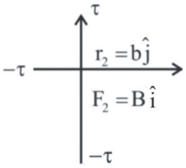


Moment due to $\tau_1 = r_1 \times F_1$

$$\tau_1 = a\hat{i}\times A\hat{j}$$

$$\tau_1 = aA\hat{k} \qquad (\because \hat{i}\times\hat{j}=\hat{k})$$

IInd case–



Moment due to F_2

$$\tau_2 = r_2 \times F_2$$

$$\tau_2 = b\hat{j}\times B\hat{i} \qquad (\because \hat{j}\times\hat{i}=-\hat{k})$$

$$\tau_2 = -bB\hat{k}$$

Net moment $\tau = \tau_1 + \tau_2$

$$= [aA + (-Bb)]\hat{k}$$

$$\tau = (aA - bB)\hat{k}$$

325. A particle of mass 15kg is moving with a uniform speed 8ms^{-1} in xy-plane along the line 3y = 4x + 10, then the magnitude of its angular momentum about the origin in kg–m^{2}s^{-1} is… $\left(\sin 53° = \frac{4}{5}\right)$

(a) 240 (b) 80

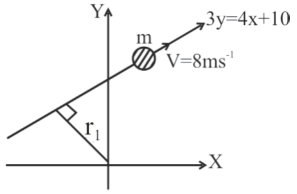
(c) 120 (d) 280

AP EAMCET (23.04.2018) Shift-2

Ans. (a) : Given,

m = 15 kg

v = 8 ms^{-1}



From figure:

3y = 4x + 10

4x–3y+10= 0 ....(i)

Comparing eq. (i) by

ax+bx+c = 0

$$\therefore r=\frac{c}{\sqrt{a^2+b^2}}=\frac{10}{\sqrt{(4)^2+(-3)^2}}$$

Angular momentum = mvr

$$=15\times8\times\left(\frac{10}{\sqrt{(4)^2+(3)^2}}\right)$$

$$=240\,\text{kg}-\text{m}^2\text{s}^{-1}$$

326. A torque of 1 N-m is applied to a wheel which is at rest. After 2 second the angular momentum in kg-m^2/s is

(a) 0.5 (b) 1

(c) 2 (d) 4

(e) 3

Kerala CEE - 2017

Ans. (c) : Given that,

Torque (τ) = 1 N-m

Time (Δt) = 2 seconds

We know that,

Angular momentum (L) = I.ω

$$L = I\,\alpha\,\Delta t \qquad [\because \omega = \alpha\,\Delta t]$$

$$L = I.\frac{\tau}{I}.\Delta t \qquad \left[\because \alpha=\frac{\tau}{I}\right]$$

$$L = \tau\,.\Delta t$$

$$L = 1\times 2$$

$L = 2$ kg-m^2/s

327. A solid sphere of mass 2 kg and radius 1 m is free to rotate about an axis passing through its centre. A constant tangential force 'F' is required to rotate the sphere with 10 rad s^{-1} in 2 s starting from rest. Then the value of F is____

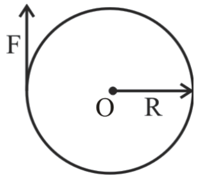
@apna_pdf

(a) 2N (b) 4N
(c) 8N (d) 10N

AP EAMCET-25.04.2017, Shift-I

Ans. (b) : Given that-

Mass (M) = 2kg
Radius (R) = 1 m
ω = 10rad/sec
t = 2sec



We know that,

$$\omega = \omega_0 + \alpha t$$
$$\omega = 0 + \alpha t$$
$$\omega = \alpha t$$
$$10 = \alpha(2)$$
$$\alpha = 5 \text{ rad/s}^2$$

Moment of inertia of solid sphere –

$$I = \frac{2}{5}MR^2$$
$$I = \frac{2}{5}\times 2\times(1)^2$$
$$I = \frac{4}{5}\text{kg} - \text{m}^2$$
$$\because \quad \tau = RF = I\alpha$$
$$\tau = 1\times F = \frac{4}{5}\times 5$$
$$F = 4N$$

328. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought into contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is

(a) $\frac{1}{2}I(\omega_1+\omega_2)^2$ (b) $\frac{1}{4}I(\omega_1-\omega_2)^2$

(c) $I(\omega_1-\omega_2)$ (d) $\frac{1}{8}(\omega_1-\omega_2)^2$

NEET- 2017

Ans. (b) : Assume the angular velocity of the combination be the ω.

We use the conservation of angular momentum

$$I\omega_1 + I\omega_2 = (I+I)\omega$$
$$\Rightarrow \quad I(\omega_1+\omega_2) = 2I\omega$$
$$\omega = \frac{\omega_1+\omega_2}{2}$$

Now, The initial kinetic energy-

$$(\text{K.E.})_i = \frac{1}{2}I\omega_1^2 + \frac{1}{2}I\omega_2^2$$

and final kinetic energy-

$$(\text{K.E.})_f = \frac{1}{2}(2I)\omega^2$$

Putting the value of ω we get-

$$(\text{K.E.})_f = \frac{I}{4}(\omega_1+\omega_2)^2$$

So, the loss of kinetic energy-

$$\Delta\text{K.E.} = (\text{K.E.})_i - (\text{K.E.})_f$$
$$= \frac{1}{2}I(\omega_1^2+\omega_2^2) - \frac{I}{4}(\omega_1^2+\omega_2^2+2\omega_1\omega_2)$$
$$= \frac{I}{4}(\omega_1^2+\omega_2^2-2\omega_1\omega_2)$$
$$\Delta\text{K.E.} = \frac{I}{4}(\omega_1-\omega_2)^2$$

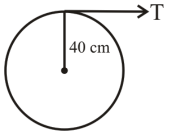
329. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder, if the rope is pulled with a force of 30 N?

(a) 25 m/s^2 (b) 0.25 rad/s^2
(c) 25 rad/s^2 (d) 5 m/s^2

NEET- 2017

Ans. (c):

Given,



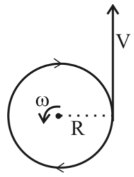
$$\tau = I\times\alpha$$

Mass (m) = 3 kg
Radius (r) = 40 cm = 0.40 m
F = 30 N

We know that,

$$\tau = I\times\alpha$$
$$Fr = I\alpha \Rightarrow F\times r = Mr^2\times\alpha \qquad (\because I = mr^2, \tau = Fr)$$
$$F = mr\alpha$$
$$30 = 3\times 0.40\times\alpha$$
$$\alpha = \frac{30}{3\times 0.40}$$
$$\alpha = \frac{100}{4} = 25\text{rad/sec}^2$$
$$\alpha = 25\text{rad/sec}^2$$

330. A girl with mass 'm' is standing at the edge of a merry-go-round having moment of inertia 'I', radius 'R' and angular velocity 'ω' as shown in figure. The girl jumps off the edge of the merry-go-round with a velocity 'v' with respect to the ground in a direction tangent to the edge. The new angular velocity of the merry-go-round is



@apna_pdf

(a) $\left[\dfrac{I\omega - mv^2}{I}\right]^{\frac{1}{2}}$

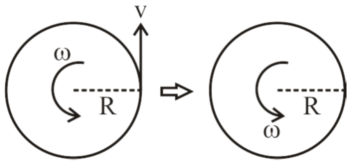
(b) $\left[\dfrac{\left(I + mR^2\right)\omega - mv^2}{I}\right]^{\frac{1}{2}}$

(c) $\left[\dfrac{I\omega - mvR}{I}\right]$

(d) $\left[\dfrac{\left(I + mR^2\right)\omega - mvR}{I}\right]$

AP EAMCET-28.04.2017, Shift-I

Ans. (d) :



Let the angular velocity of the merry-go-round be ω'

So, Initial angular momentum, $L_i = I\omega + mR^2\,\omega$

And, final angular momentum $L_f = I\omega' + mvR$

Hence, conservation of angular momentum–

$$L_i = L_f$$

$$I\omega + mR^2\,\omega = I\omega' + mvR$$

$$I\omega + mR^2\,\omega - mvR = I\omega'$$

$$(I + mR^2)\omega - mvR = I\omega'$$

$$\omega' = \frac{\left(I + mR^2\right)\omega - mvR}{I}$$

331. A circular disc is rotating with angular velocity ω. A man standing at the edge walks towards the centre of the disc then the angular velocity is ω.

(a) Decreases (b) Increases

(c) No change (d) Halved

SRMJEEE-2017

Ans. (b) : If no external force acting on a body it's angular momentum remains constant.

J = Iω = constant

Where, I = moment of Inertia of body

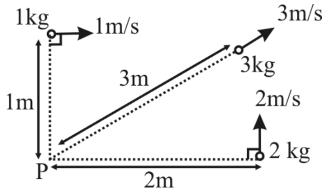
ω = angular velocity

For disc, $I = \frac{1}{2}MR^2$

Then, $J = \frac{1}{2}MR^2\omega$ = constant

As Radius decreases then angular velocity will increases.

332. Three small balls of masses 1kg, 2kg and 3kg are moving in a plane and their velocities are 1m/s, 2m/s and 3m/s, respectively as shown. The total angular momentum of the system of three ball about point P at given instant of time is

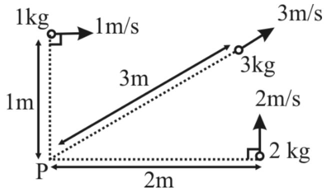


(a) 8 kgm^2/s (b) 9 kgm^2/s

(c) 36 kgm^2/s (d) 7 kgm^2/s

UPSEE - 2017

Ans. (d) :



According to the diagram total angular momentum,

$\vec{L}$ = (2×2×2 sin90°) + (3×3×3×sin0°) –(1×1×1× sin90°)

$\vec{L}$ = (8×1)+ (27×0) –(1×1)

$\vec{L}$ = 8 – 1

$\vec{L}$ = 7 kgm^2/sec

333. If a body of moment of inertia 2 kg m^2 revolves about its own axis making 2 rotations per second, then its angular momentum (in Js) is

(a) 2 π (b) 4 π

(c) 6 π (d) 8 π

(e) 10 π

Kerala CEE - 2016

Ans. (d) : Given:

Moment of inertia (I) = 2 kg-m^2

Axis rotation (f) = 2 rps

We know that,

Angular momentum, L = Iω

L = 2 × 2πf (∵ ω = 2πf)

L = 2 × 2π × 2

L = 8π Js

334. Angular momentum of the Earth revolving around the Sun in a circular orbit of radius R is proportional to

(a) $\sqrt{R}$ (b) R

(c) R^2 (d) $R^{1/3}$

(e) $R^{3/2}$

Kerala CEE - 2015

Ans. (a) : We know that,

Angular momentum of Earth, L = mvR

Now, $\dfrac{mv^2}{R} = \dfrac{GMm}{R^2}$

$$v^2 = \frac{GM}{R}, \quad v = \sqrt{\frac{GM}{R}}$$

So, $L = m\sqrt{\dfrac{GM}{R}} \times R = m\sqrt{GMR}$

∴ $L \propto \sqrt{R}$

@apna_pdf

335. The angular momentum of a particle describing uniform circular motion is L. If its kinetic energy is halved and angular velocity doubled, its new angular momentum is

(a) 4 L (b) $\frac{L}{4}$

(c) $\frac{L}{2}$ (d) 2 L

(e) $\frac{L}{8}$

UPSEE-2005, Kerala CEE - 2011

Ans. (b) :

Kinetic energy $(K) = \frac{1}{2}I\omega^2$

$$K = \frac{1}{2}(I\omega)\omega$$

Angular momentum (L) = Iω

$$\therefore \quad K = \frac{1}{2}L\omega$$

$$L = \frac{2K}{\omega} \qquad \text{...(i)}$$

Second condition $\omega' = 2\omega, K' = \frac{K}{2}$

New angular momentum

$$L' = \frac{2K'}{\omega'}$$

$$L' = \frac{2\left(\frac{K}{2}\right)}{(2\omega)} = \frac{K}{2\omega}$$

$$L' = \frac{1}{4}\left(\frac{2K}{\omega}\right)$$

$$L' = \frac{L}{4} \qquad \text{.....(ii)}$$

By comparing from equation (i) and (ii)

$$L' = \frac{L}{4}$$

336. If the earth were to contract such that its radius becomes one quarter, without change in its mass, the duration of one full day would be

(a) 3 h (b) 1.5 h

(c) 6 h (d) 4 h

(e) 2 h

Kerala CEE 2007

Ans. (b) : $M_1 = M_2 = M$ [Mass of Earth]

$$R_2 = \frac{1}{4}R_1$$

$$T_1 = 24\text{hrs}$$

By the law of conservation of angular momentum

Iω = Constant

$I_1\omega_1 = I_2\omega_2$

$$\frac{2}{5}MR_1^2\omega_1 = \frac{2}{5}MR_2^2\omega_2$$

$$\frac{2}{5}M\left(R_1^2\omega_1\right) = \frac{2}{5}M\left(R_2^2\omega_2\right)$$

$$\left(\because \omega = \frac{2\pi}{T}\right)$$

$$R_1^2 \times \frac{2\pi}{24} = \frac{R_1^2}{16} \times \frac{2\pi}{T_2}$$

$$2\pi R_1^2\left(\frac{1}{24}\right) = \frac{2\pi R_1^2}{16 \times T_2}$$

$$T_2 = \frac{24}{16}$$

$$T_2 = \frac{3}{2}$$

$$T_2 = 1.5\text{ h}$$

337. Moment of a couple is called:

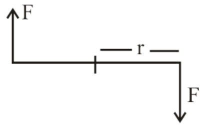
(a) Impulse (b) Couple

(c) Torque (d) Angular momentum

(e) None of these

Kerala CEE 2004

Ans. (c) : The moment of a couple is called torque.



Torque is a couple of force acting in opposite direction. It's multiplication of force and length from centre to edge

T = F ×r

338. A disc of mass 2 kg and radius 0.2 m is rotating with angular velocity 30 rads^{-1} what is angular velocity, if a mass of 0.25 kg is put on periphery of the disc?

(a) 24 rad s^{-1} (b) 36 rad s^{-1}

(c) 15 rad s^{-1} (d) 26 rad s^{-1}

UPSEE - 2015

Ans. (a): Given,

$m_1 = 2$ kg

$m_2 = 0.25$ kg

$r = 0.2$ m

$\omega_1 = 30$ rad/sec

According to law of conservation of angular momentum

$L = I\omega = \text{Constant}$

$\therefore \quad I_1\omega_1 = I_2\omega_2$

$$\frac{1}{2}m_1r^2\omega_1 = \frac{1}{2}(m_1 + 2m_2)r^2 \times \omega_2$$

$$\frac{1}{2} \times 2 \times (0.2)^2 \times 30 = \frac{1}{2} \times (2 + 2 \times 0.25) \times (0.2)^2 \times \omega_2$$

$$1.2 = 0.05\omega_2$$

$\therefore \quad \omega_2 = 24$ rad/sec

@apna_pdf

339. A particle of mass m = 5 unit is moving with a uniform speed $v = 3\sqrt{2}$ unit in the XOY plane along the line y = x + 4. The magnitude of the angular momentum of the particle about the origin is

(a) 60 unit (b) $40\sqrt{2}$ unit
(c) Zero (d) 7.5 unit

UPSEE - 2014

Ans. (a) : Given,

Mass (m) = 5unit

Speed (v) = $3\sqrt{2}$ unit

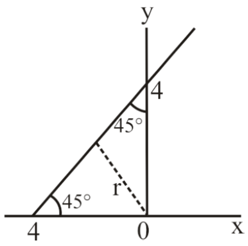
Direction of momentum y = x+4

The slope of the line can be obtained by comparing with the equation of the straight line

$y = mx + c$

$m = \tan\theta = 1$

$\theta = 45^\circ$



Perpendicular distance of this line from the origin

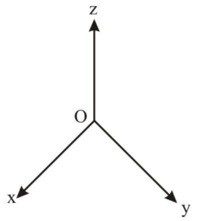
$$r = 4\sin 45^\circ = \frac{4}{\sqrt{2}} = 2\sqrt{2}$$

Angular momentum about origin (L) = mvr

$$= 5\times3\sqrt{2}\times2\sqrt{2}$$

= 60 units

340. A force of $-F\hat{k}$ acts on O, the origin of the coordinate system. The torque about the point (1, –1) is

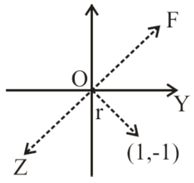


(a) $F(\hat{i}-\hat{j})$ (b) $-F(\hat{i}+\hat{j})$
(c) $F(\hat{i}+\hat{j})$ (d) $-F(\hat{i}-\hat{j})$

UPSEE - 2007

Ans. (c) : Given, $\vec{F} = -F\hat{k}$

$$\vec{r} = (\hat{i}-\hat{j})$$



The torque acting on the Particle

$$\vec{\tau} = \vec{r}\times\vec{F}$$

According to the figure,

$$\vec{\tau} = (\hat{i}-\hat{j})\times(-F\hat{k})$$

$$\vec{\tau} = F\left[\left(-\hat{i}\times\hat{k}\right)+\left(\hat{j}\times\hat{k}\right)\right]$$

$$\vec{\tau} = F\left[\hat{j}+\hat{i}\right] \quad \left[\begin{array}{l}\because \text{Where}, -\hat{i}\times\hat{k} = \hat{j}\\ \text{And } \hat{j}\times\hat{k} = \hat{i}\end{array}\right]$$

$$\vec{\tau} = F(\hat{i}+\hat{j})$$

341. What is moment of inertia in terms of angular momentum (L) and kinetic energy (K)?

(a) $\frac{L^2}{K}$ (b) $\frac{L^2}{2K}$
(c) $\frac{L}{2K^2}$ (d) $\frac{L}{2K}$

UPSEE - 2006

Ans. (b) : Angular momentum of rigid body, $L = I\omega$

Kinetic energy, $K = \frac{1}{2}I\omega^2$

$$K = \frac{1}{2I}\times I^2\omega^2$$

$$K = \frac{1}{2I}(I\omega)^2$$

$$K = \frac{L^2}{2I}$$

$$\therefore \quad I = \frac{L^2}{2K} \quad (I = \text{Moment of inertia})$$

342. A constant torque of 31.4 N-m is exerted on a pivoted wheel. If angular acceleration of wheel is 4π rad/s^2, then the moment of inertia of the wheel is

(a) 2.5 kg m^2 (b) 3.5 kg m^2
(c) 4.5 kg m^2 (d) 5.5 kg m^2

BITSAT-2011
AIIMS-2001

Ans. (a) : Given;

τ = 31.4 N-m

$\alpha = 4\pi$ rad/sec^2

We know that

$$\tau = I.\alpha$$

$$\therefore \quad I = \frac{\tau}{\alpha}$$

$$I = \frac{31.4}{4\pi} = \frac{31.4}{4\times3.14}$$

I = 2.5 kg m^2

343. A particle of mass 'm' is projected with a velocity v making an angle of 30° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height 'h' is

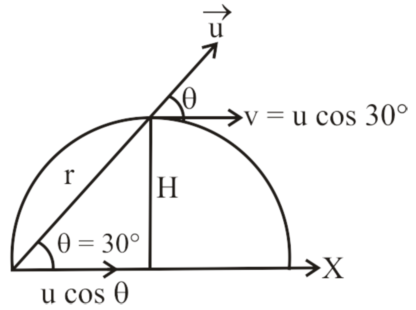
@apna_pdf

(a) $\frac{\sqrt{3}}{2}\frac{mv^2}{g}$ (b) Zero

(c) $\frac{mv^3}{\sqrt{2g}}$ (d) $\frac{\sqrt{3}}{16}\frac{mv^3}{g}$

BITSAT-2013

Ans. (d) : Given:



Angle, θ = 30°

Maximum height

$$H=\frac{v^2\sin^2\theta}{2g}$$

$$H=\frac{v^2\sin^2 30°}{2\times g}$$

$$H=\frac{v^2}{8g}$$

Now, linear momentum,

$$P = mv\cos 30°$$

$$P=\frac{\sqrt{3}}{2}mv$$

Angular moment of projectile about point of projection by

$$L = rmv\cos\theta \qquad (\because r = H)$$

$$L = mvH\cos 30°$$

$$L = P.H$$

$$L=\frac{\sqrt{3}}{2}\times mv\times\frac{v^2}{8g}$$

$$L=\frac{\sqrt{3}\,mv^3}{16g}$$

344. Angular momentum of an electron in an excited hydrogen atom having energy –3.4eV is

(a) 1.7×10^{-34} Js (b) 2.1×10^{-34} Js

(c) 3.9×10^{-34} Js (d) 4.1×10^{-35} Js

CG PET- 2015

Ans. (b) : Given:

$$E_n = -3.4\text{eV}$$

$$\tau = 1 \text{ (hydrogen atom)}$$

Energy of an electron in nth state is

$$E_n = -\frac{13.6}{n^2}$$

$$-3.4 = -\frac{13.6}{n^2}$$

$$n^2 = \frac{13.6}{3.4}$$

$$n^2 = 4$$

$$n = 2$$

Angular momentum,

$$L=\frac{nh}{2\pi} \quad [\because \text{Plank constant (h)} = 6.626\times10^{-34}\text{ J/sec}]$$

$$L=\frac{6.626\times10^{-34}\times 2}{2\times3.14}$$

$$L = 2.1\times10^{-34}\text{ J/sec}$$

345. A particle of mass m is projected with velocity v at an angle 45° with the horizontal. The magnitude of angular momentum of the particle about the point of projection, at highest point of flight is

(a) $mv^2/2g$ (b) $mv^3/2\sqrt{g}$

(c) $mv^3/4\sqrt{2}g$ (d) Zero

CG PET- 2011

Ans. (c) : Given,

Angle, θ = 45°

We know maximum height,

$$H=\frac{v^2\sin^2\theta}{2g}$$

$$H=\frac{v^2\sin^2 45°}{2g}$$

$$H=\frac{v^2}{4g}$$

Momentum of particle at the heights point–

$$p = mv\cos\theta$$

$$p = mv\cos 45°$$

$$p=\frac{mv}{\sqrt{2}}$$

Angular momentum of the particle about the point of projection

$$L = p\times H$$

$$L=\frac{mv}{\sqrt{2}}\times\frac{v^2}{4g}$$

$$L=\frac{mv^3}{4\sqrt{2}g}$$

346. If the torque of the rotational motion by zero, then the constant quantity will be

(a) angular momentum

(b) linear momentum

(c) angular acceleration

(d) centripetal acceleration

CG PET- 2009

Ans. (a) : When the torque acting upon a system is zero, the angular momentum is constant and hence is conserved.

$$\tau=\frac{dL}{dt}$$

@apna_pdf

If $\tau_{net} = 0$

$$\frac{dL}{dt} = 0$$

$$L = \text{Constant}$$

Hence, net torque is zero implies angular momentum is constant.

347. A particle of mass m is circulating on a circle of radius r having angular momentum L, then the centripetal force will be

(a) L^2/mr (b) L^2m/r

(c) L^2/mr^3 (d) L^2/mr^2

CG PET- 2009, 2011

Ans. (c) : Angular momentum is given by

L = radius × linear momentum

$$L = r \times p$$

$$L = r \times m \times v \qquad [\because p = mv]$$

$$\Rightarrow \qquad v = \frac{L}{mr}$$

Now, as centripetal force, $F_c = \frac{mv^2}{r}$

Putting the value of v we get,

$$F_c = \frac{m}{r}\left[\frac{L}{mr}\right]^2 = \frac{L^2}{mr^3}$$

348. The rotational kinetic energy of a body is KE and its moment of inertia is I. The angular momentum is

(a) KEI (b) $2\sqrt{KEI}$

(c) $\sqrt{2KEI}$ (d) KE/I

CG PET- 2007

Ans. (c) : Rotational kinetic energy–

$$K.E = \frac{1}{2}I\omega^2 \qquad ....(i)$$

Angular momentum

$$L = I\omega$$

$$L^2 = I^2\omega^2 \Rightarrow \omega^2 = \frac{L^2}{I^2}$$

Putting the value of ω^2 in equation (i) we get–

$$KE = \frac{1}{2}I \times \frac{L^2}{I^2}$$

$$\frac{2KE}{I} = \frac{L^2}{I^2}$$

$$L^2 = 2KEI$$

$$L = \sqrt{2KEI}$$

349. A particle is moving in the XY- plane with constant velocity along a line parallel to the X-axis. Its angular momentum about the Z- axis

(a) is zero (b) remains constant

(c) goes on increasing (d) goes on decreasing

CG PET- 2004

Ans. (c) : Angular momentum of a particle is given by

$$L = mvr$$

$$L \propto r$$

As particle is moving along axis its perpendicular distance will be r from Z-axis.

As the distance of particle (r) from the Z-axis is increasing therefore angular momentum of a particle will also goes on increasing.

350. A wheel is rotating with an angular speed of 20 rad/s. It is stopped to rest by applying a constant torque is 4s. If the moment of inertia of the wheel about its axis is 0.20 kg-m^2, then the work done by the torque in two seconds will be

(a) 13 J (b) 20 J

(c) 30 J (d) 40 J

Manipal UGET-2014

Ans. (c) : Given that,

$I = 0.20$ kg-m^2

$\omega_1 = 20$ rad/sec, $\omega_2 = 0$

$t = 4$ sec

Angular retardation in time t is given by–

$$\omega_2 = \omega_1 - \alpha t$$

$$\alpha t = \omega_1 - \omega_2$$

$$\alpha = \frac{\omega_1 - \omega_2}{t}$$

After putting the given values, we get–

Angular retardation $\alpha = \frac{20-0}{4}$

$$\alpha = 5 \text{ rad/s}^2$$

Angular speed after 2 sec–

$$\omega_2 = \omega_1 - \alpha t$$

$$= 20 - 5 \times 2$$

$$\omega_2 = 10 \text{ rad/sec}$$

Work done by torque in 2 sec = Loss in K.E.

$$= \frac{1}{2}I(\omega_1^2 - \omega_2^2)$$

$$= \frac{1}{2} \times 0.20 \times (20^2 - 10^2)$$

$$= 0.10 \times 300$$

Work done = 30 J

351. Angular momentum is conserved

(a) Always

(b) never

(c) when external force is absent

(d) when external torque is absent

Manipal UGET-2013

Ans. (d) : Conservation of linear momentum where it is conserved if there is no external force. Angular momentum is conserved if there is no external torque or when external torque is absent.

352. A circular disc is rotating with angular velocity ω. If a man standing at the edge of the disc walks towards its centre then the angular velocity of the disc will

(a) decrease (b) increase

(c) be halved (d) not change

Manipal UGET-2013

@apna_pdf

Ans. (b) : Law of conservation of angular momentum

$$L = I\omega = \text{constant}$$

Moment of inertia of disc–

$$I = \frac{1}{2}MR^2$$

$$L = \frac{1}{2}MR^2\omega = \text{constant or } \omega \propto \frac{1}{R^2}$$

Since, man moves toward the center of the disc, distance of mass distribution R decreases hence ω increases.

353. If the angular momentum of any rotating body increases by 200%, then the increase in its kinetic energy is

(a) 400 % (b) 800 %
(c) 200 % (d) 100 %

Manipal UGET-2012

Ans. (b) :

$$\text{Kinetic energy } K_1 = \frac{L_1^2}{2I}, K_2 = \frac{L_2^2}{2I}$$

When the angular momentum of body is increased by 200%,

$$L_2 = L_1 + L_1 \times \frac{200}{100}$$

$$L_2 = 3L_1$$

$$\frac{L_2}{L_1} = 3$$

$$\frac{K_2}{K_1} = \left(\frac{L_2}{L_1}\right)^2 = (3)^2$$

$$K_2 = 9K_1$$

Then increases in kinetic energy

$$= \frac{K_2 - K_1}{K_1} = \frac{9K_1 - K_1}{K_1} \times 100$$

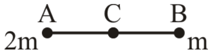
$$= 800\%$$

354. Two balls of masses m and 2m are attached to the ends of a light rod of length L. The rod rotates with an angular speed ω about an axis passing through the centre of mass of system and perpendicular to the plane. Find the angular momentum of the system about the axis of rotation.

(a) $\frac{2}{3}m\omega L^2$ (b) $\frac{1}{3}\omega^2 Lm$
(c) $\frac{2}{3}\omega^2 Lm$ (d) $\frac{1}{3}Lm$

JCECE-2016

Ans. (a) :



$$X_{CM} = \frac{2m \times 0 + m \times L}{2m + m} = \frac{L}{3}$$

So, the velocity of ball–

$$V_A = \omega X_{CM} = \frac{\omega L}{3}$$

$$V_B = \omega(L - X_{CM})$$

$$V_B = \omega L - \omega X_{CM}$$

$$V_B = \omega L - \omega\frac{L}{3}$$

$$V_B = \frac{2\omega L}{3}$$

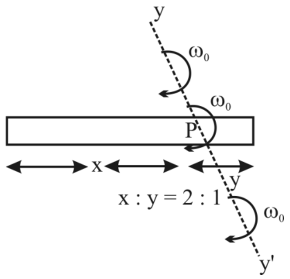
The angular momentum of a system about C

$$L = 2m\,(V_A \times X_{CM}) + mV_B\,(L - X_{CM})$$

$$= 2m \times \frac{\omega L}{3} \times \frac{L}{3} + m \times \frac{2\omega L}{3} \times \frac{2L}{3}$$

$$L = \frac{2m\omega L^2}{3}$$

355. A uniform rod of mass m and length L is rotated about an axis passing through the point P as shown in figure. The magnitude or angular momentum of the rod about the rotational axis yy' passing through the point P is



(a) $\frac{ML^2}{18}$ (b) $\frac{M(x+y)^2}{9}$
(c) $\frac{M(L^2 \times x^2)}{9}$ (d) $\frac{M(L^2 + 2y^2)}{18}$

JCECE-2015

Ans. (b) : Given that,

$$\frac{x}{y} = \frac{2}{1}$$

Add 1 on both side we get–

$$\frac{x}{y} + 1 = \frac{2}{1} + 1$$

$$\frac{x+y}{y} = \frac{3}{1}$$

$$y = \frac{x+y}{3} = \frac{L}{3}$$

$$x = 2y = \frac{2L}{3}$$

$$I_P = I_{CM} + M(d)^2$$

$$= \frac{ML^2}{12} + M\left(\frac{L}{2} - \frac{L}{3}\right)^2 = \frac{ML^2}{12} + \frac{ML^2}{36}$$

$$I_p = \frac{4ML^2}{36} = \frac{ML^2}{9}$$

$$I_p = \frac{M(x+y)^2}{9}$$

@apna_pdf

356. **Total angular momentum of a rotating body remains constant, if the net torque acting on the body is :**

(a) zero (b) maximum

(c) minimum (d) unity

JCECE-2005

Ans. (a) : If a body is rotating with constant angular momentum then, the net torque on the body will be zero.

$$\tau = \frac{dL}{dT} = 0$$

$$L = I\omega = \text{constant}$$

Hence, for net torque zero angular momentum L will be constant.

357. **A person sitting firmly over a rotating stool has his arms stretched. If he folds his arms, his angular momentum about the axis of the rotation**

(a) Increase

(b) Decreases

(c) Remains unchanged

(d) Doubles

COMEDK 2015

Ans. (c) :

Since we know that relation between external torque and angular momentum is given as:

$$\tau_{ext} = \frac{d\vec{L}}{dt}$$

If external torque will be zero $\tau_{ext} = 0$

$$\Rightarrow \vec{L} = \text{constant}$$

So, If person folds his arm, his angular momentum about the axis of rotation remains unchanged because there is no external torque.

358. **Assertion:** For the planets orbiting around the sun, angular speed, linear speed and K.E. change with time, but angular momentum remains constant.

Reason: No torque is acting on the rotating planet. So its angular momentum is constant.

(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

AIIMS-2013

Ans. (a) : The torque on a body is given by

$$\tau = \frac{dL}{dt}$$

When,

$$\tau = 0$$

$$\Rightarrow \frac{dL}{dt} = 0$$

$$\Rightarrow L = \text{constant}$$

359. **Assertion:** There are very small sporadic changes in the speed of rotation of the earth

Reason: Shifting of large air masses in the earth's atmosphere produce a change in the moment of inertia of the earth causing its speed of rotation to change.

(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

(e) Assertion is incorrect but the Reason is correct.

AIIMS-2004

Ans. (a) : Since particles of atmosphere also revolves around the axis of rotation along with earth. Now due to change in the constitution of atmosphere there is small change in the total moment of inertia of the whole system.

According the conservation of angular momentum.

$I\omega = I'\omega'$.

There is corresponding change in the angular velocity of the system if I' changes.

360. **Assertion:** For a system of particles under central force field, the total angular momentum is conserved.

Reason: The torque acting on such a system is zero.

(a) Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

(e) Assertion is incorrect but the Reason is correct.

AIIMS-2005

Ans. (a): For a system of particles under central force field, force acts along the line joining the bodies. So, it does not have rotatory effect (i.e. torque is zero). So, angular momentum is conservative.

Due to central force,

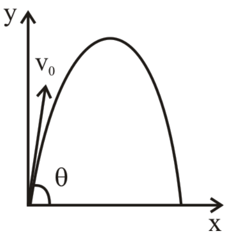
$$\tau = 0$$

$$\Rightarrow \frac{dL}{dt} = 0$$

$$\Rightarrow L = \text{constant}$$

361. **A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity v_0 in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is**

@apna_pdf



(a) $-mg v_0 t^2 \cos\theta \hat{j}$ (b) $mg v_0 t \cos\theta \hat{k}$

(c) $-\frac{1}{2} mg v_0 t^2 \cos\theta \hat{k}$ (d) $\frac{1}{2} mg v_0 t^2 \cos\theta \hat{i}$

AIIMS-2016

Ans. (c) : We know,
The angular momentum of the particle about the origin is

$$(\vec{L}) = m(\vec{r} \times \vec{v})$$

$$\vec{L} = m\left[v_0 \cos\theta t \hat{i} + \left(v_0 \sin\theta t - \frac{1}{2} g t^2\right)\hat{j}\right] \times \left[v_0 \cos\theta \hat{i} + (v_0 \sin\theta - gt)\hat{j}\right]$$

$$= m v_0 \cos\theta t \left[-\frac{1}{2} g t\right]\hat{k}$$

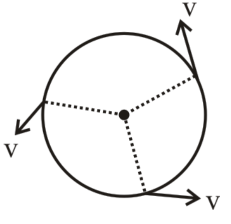
$$= -\frac{1}{2} m g v_0 t^2 \cos\theta \hat{k}$$

362. In an orbital motion, the angular momentum vector is:

(a) along the radius vector
(b) parallel to the linear momentum
(c) in the orbital plane
(d) perpendicular to the orbital plane

AIIMS-2004
Odisha PMT-2004

Ans. (d) : In an orbital motion, when a body is rotating about an axis. Then, the sum of the moment of the linear moment of all the particles about the given axis is called angular momentum of the body about the axis. Angular momentum is vector quantity.



$$\begin{bmatrix} I = mr^2 \\ v = r\omega \end{bmatrix}$$

$$\vec{J} = \vec{r} \times \vec{p} = rp \sin\theta \hat{\theta}$$

$$J = I\omega \Rightarrow mvr \quad (\because \theta = 90^\circ)$$

As direction of velocity is ⊥ to orbital plane and $J \propto v$.
Therefore, in an orbital motion the angular momentum vector is perpendicular to the orbital plane.

363. A horizontal platform is rotating with uniform angular velocity around the vertical axis passing through its centre. At some instant of time a viscous fluid of mass m is dropped at the centre and is allowed to spread out and finally fall. The angular velocity during this period:

(a) decreases continuously
(b) decreases initially and increases again
(c) remains unaltered
(d) increases continuously

AIIMS-2004

Ans. (b) : The moment of inertia of the system is increased, when the fluid spreads out.
According law of conservation of angular momentum,

$$I_1\omega_1 = I_2\omega_2$$

As moment of inertia (I) increases due to water spreading out, the angular velocity (ω) decreases. As soon as water level fall, moment of inertia (I) decreases and angular velocity (ω) increases.

364. The motion of planets in the solar system is an example of the conservation of:

(a) Mass (b) Linear momentum
(c) Angular momentum (d) Energy

AIIMS-2003

Ans. (c) : The motion of planets in the solar system is an example of the conservation of angular momentum because no internal torque acts on the system.

365. If there is change of angular momentum from 1J to 5J in 5 second. Then the torque is:

(a) $\frac{3J}{5}$ (b) $\frac{4J}{5}$

(c) $\frac{5J}{4}$ (d) none of these

AIIMS-1997

Ans. (b) : Given,
Final angular momentum (L_2) = 5J
Initial angular momentum (L_1) = 1 J
time (t) = 5 sec
We know,

$$\text{Torque } (\tau) = \frac{dL}{dt}$$

Where,
dL = change in angular momentum
dt = change in time

$$\tau = \frac{5-1}{5} = \frac{4}{5}$$

$$\tau = \frac{4}{5} \text{ J}$$

Hence,
The required torque is $\frac{4}{5}$ J.

366. If torques of equal magnitudes are applied to a hollow cylinder and a solid sphere both having the same mass and radius. The cylinder is free to rotate about its standard axis of symmetry and the sphere is free to rotate about an axis passing through its centre. Which of the two will acquire a greater angular speed after a given time?

(a) $\omega_1 > \omega_2$ (b) $\omega_1 = \omega_2$

(c) $\omega_2 > \omega_1$ (d) None of these

BCECE-2015

@apna_pdf

Ans. (c) : Consider I_1 and I_2 be the moments of inertia of the hollow cylinder and solid sphere about its axis through its centre respectively.

Then, $$I_1 = MR^2 \quad \text{...(i)}$$

and $$I_2 = \frac{2}{5}MR^2 \quad \text{...(ii)}$$

Let τ be the magnitude of the torque applied on each of them. If α_1 and α_2 are the angular accelerations produced in the cylinder and sphere respectively. Then,

$$\tau = I_1\alpha_1$$

and $$\tau = I_2\alpha_2$$

$$\therefore \quad I_1\alpha_1 = I_2\alpha_2 \Rightarrow \frac{\alpha_1}{\alpha_2} = \frac{I_2}{I_1}$$

$$\frac{\alpha_1}{\alpha_2} = \frac{\frac{2}{5}MR^2}{MR^2} = \frac{2}{5} \Rightarrow \alpha_2 = \frac{5}{2}\alpha_1$$

$$\alpha_2 = 2.5\alpha_1 \quad \text{...(iii)}$$

If ω_1 and ω_2 be the angular speed of the cylinder and sphere after time t. Then,

$$\omega_1 = \omega_0 + \alpha_1 t \quad \text{...(iv)}$$

and $$\omega_2 = \omega_0 + \alpha_2 t$$

$$\omega_2 = \omega_0 + 2.5\alpha_1 t \quad \text{...(v)}$$

where, ω_0 = initial angular speed

From Eq. (iv) and (v), it is clear that

$$\omega_2 > \omega_1$$

Hence, the sphere will acquire more angular speed as compared to that of the cylinder after a given time.

367. What is the torque of force $\vec{F} = -3\hat{i} + \hat{j} + 5\hat{k}$ acting at point whose position vector is $\vec{r} = 7\hat{i} + 3\hat{j} + \hat{k}$?

(a) $14\hat{i} - 38\hat{j} + 16\hat{k}$ (b) $4\hat{i} + 4\hat{j} + 6\hat{k}$

(c) $-14\hat{i} + 38\hat{j} - 16\hat{k}$ (d) $-21\hat{i} + 3\hat{j} + 5\hat{k}$

BCECE-2009

Ans. (c) : Given that,

$$\vec{F} = -3\hat{i} + \hat{j} + 5\hat{k}$$

$$\vec{r} = 7\hat{i} + 3\hat{j} + \hat{k}$$

We know,

$$\text{Torque } (\vec{\tau}) = \vec{r} \times \vec{F}$$

$$\tau = (7\hat{j} + 3\hat{j} + \hat{k}) \times (-3\hat{i} + \hat{j} + 5\hat{k})$$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -3 & 1 & 5 \\ 7 & 3 & 1 \end{vmatrix}$$

$$\vec{\tau} = -14\hat{i} + 38\hat{j} - 16\hat{k}$$

368. A force $\vec{F} = a\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of a for which angular momentum is conserved is–

(a) zero (b) 1

(c) –1 (d) 2

BCECE-2010

Ans. (c) : When angular momentum is conserved then the torque (τ) is zero

We know,

$$\vec{\tau} = \vec{F} \times \vec{r}$$

$$0 = (a\hat{i} + 3\hat{j} + 6\hat{k}) \times (2\hat{i} - 6\hat{j} - 12\hat{k})$$

From properties of cross product of two vectors,

$$\frac{a}{2} = \frac{3}{-6} \qquad \left[\frac{a_1}{a_2} = \frac{b_1}{b_2}\right]$$

$$a = \frac{6}{-6}$$

$$a = -1$$

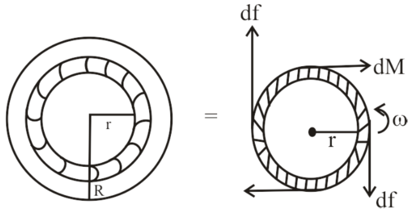
369. A uniform disc of mass M and radius R is spinned to angular velocity ω and then carefully placed on a horizontal surface (coefficient of friction is μ). Assume that the pressure exerted by disc on the surface is uniform. What is the net torque acting on disc?

(a) $\frac{2\mu MgR}{3}$ (b) $\frac{\mu MgR}{3}$

(c) $\frac{3\mu MgR}{2}$ (d) None of the above

SCRA-2012

Ans. (a) :



$$df = \mu(dm).g$$

Let σ is areal density, then

$$df = \mu\sigma 2\pi r\, gdr$$

For a small section Torque,

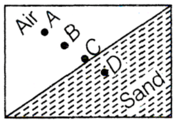
$$d\tau = rdf = \mu\sigma 2\pi\, gr^2 dr$$

$$\tau = \int d\tau = \mu g\sigma 2\pi \int_0^R r^2 dr$$

$$\tau = \mu g \frac{M}{\pi R^2} 2\pi \frac{R^3}{3} \qquad \left[\because \sigma = \frac{M}{\pi R^2}\right]$$

$$\tau = \frac{2}{3}\mu gRM$$

370. Which of the points is likely position of the centre of mass of the system shown in the figure?



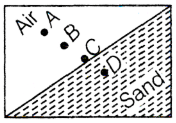
(a) A (b) D

(c) B (d) C

Karnataka CET-2016

@apna_pdf

Ans. (b): We know that the center of mass will slightly shift towards the heavy mass side. From the figure, it is clear that more mass lies on the right side of the given figure. So, centre of mass be at D.



371. **A force $F = 5\hat{i} + 2\hat{j} - 5\hat{k}$ acts on a particle whose position vector is $r = \hat{i} - 2\hat{j} + \hat{k}$. What is the torque about the origin?**

(a) $8\hat{i} + 10\hat{j} + 12\hat{k}$
(b) $8\hat{i} + 10\hat{j} - 12\hat{k}$
(c) $8\hat{i} - 10\hat{j} - 8\hat{k}$
(d) $10\hat{i} - 10\hat{j} - \hat{k}$

Karnataka CET-2014

Ans. (a) : Given, $F = 5\hat{i} + 2\hat{j} - 5\hat{k}$, $r = \hat{i} - 2\hat{j} + \hat{k}$

We know,

Torque $(\tau) = r \times F$

$$\tau = \begin{vmatrix} i & j & k \\ 1 & -2 & 1 \\ 5 & 2 & -5 \end{vmatrix}$$

$$\tau = \hat{i}(10-2) - \hat{j}(-5-5) + \hat{k}(2+10)$$

$$\tau = 8\hat{i} + 10\hat{j} + 12\hat{k}$$

372. **A door 1.6 m wide requires of a force of 1 N to be applied at the free end to open or close it. The force that is required at a point 0.4 m distance from the hinges for opening or closing the door is :**

(a) 1.2 N
(b) 3.6 N
(c) 2.4 N
(d) 4 N

Karnataka CET-2009

Ans. (d) : Given that, $r_1 = 1.6$ m, $r_2 = 0.4$m, $F_1 = 1$N

$F_2 = ?$

Torque required to open closed door will remain constant.

$$r_1 \times F_1 = r_2 \times F_2$$

$$1.6 \times 1 = 0.4 \times F_2$$

$$\frac{1.6}{0.4} = F_2$$

$$F_2 = 4\text{N}$$

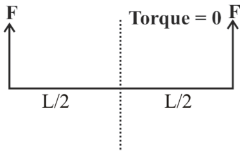
373. **When torque acting upon a system is zero which of the following will be constant?**

(a) Force
(b) Linear momentum
(c) Linear impulse
(d) None of these

J&K CET- 2002

Ans. (d): When the total external torque acting on the system zero,

Then the total angular momentum of the system is conserved.



374. **If a gymnast sitting on a rotating stool with his arms outstretched, suddenly lowers his hands.**

(a) the angular velocity decreases
(b) his moment of inertia decreases
(c) the angular velocity stays constant
(d) the angular momentum increases

J&K CET- 2002

Ans. (b): As the gymnast lowers his hands, the radius of gyration decreases and hence moment of inertia also decreases.

Angular momentum remains conserved and hence angular velocity increases.

375. **If the radius of the earth contracts to half of its present day value without change in mass, what will be the length of the day?**

(a) 24 hours
(b) 48 hours
(c) 6 hours
(d) 12 hours

J&K CET- 2002

Ans. (c): Present angular momentum of earth

$$L_1 = I\omega_1$$

$$L_1 = \frac{2}{5}MR^2\omega_1$$

New angular momentum because of change in radius

$$L_2 = I\omega_2$$

$$L_2 = \frac{2}{5}M\left(\frac{R}{2}\right)^2 \times \omega_2$$

Torque is zero then angular momentum must be conserved.

$$L_1 = L_2$$

$$\frac{2}{5}MR^2\omega_1 = \frac{1}{4} \times \frac{2}{5}MR^2\omega_2$$

$$\omega_1 = \frac{\omega_2}{4}$$

$$\frac{\omega_1}{\omega_2} = \frac{1}{4}$$

As we know,

$$\text{Time period } (T_1) = \frac{2\pi}{\omega_1} \text{ and } (T_2) = \frac{2\pi}{\omega_2}$$

Then,

$$\frac{T_2}{T_1} = \frac{\omega_1}{\omega_2}$$

$$T_2 = \frac{\omega_1 \times T_1}{\omega_2}$$

$$T_2 = \frac{T_1}{4}$$

As the actual duration of the day, $T_1 = 24$ hour

So, $$T_2 = \frac{1 \times 24}{4}$$

$$T_2 = 6\text{h}$$

@apna_pdf

376. The conservation of angular momentum demands that

(a) the external force on the system must be zero
(b) the external torque on the system must be zero
(c) both the external force as well as the external torque must be zero
(d) neither of them must be zero

J&K-CET-2013

Ans. (b): If the net torque is zero then angular momentum is constant or conserved.

377. The angle between the linear momentum and angular momentum of a particle moving along a circle is

(a) 0° (b) 45°
(c) 90° (d) 180°

J&K-CET-2016

Ans. (c) : Linear momentum is in the plane of the circle and angular momentum is in a plane Perpendicular to the plane of the circle.
Hence, the angle between the linear momentum and angular momentum of a particle moving along a circle is 90^o.

378. A particle is undergoing uniform circular motion with angular momentum L. While moving on the same path if its kinetic energy becomes four times, then its angular momentum will be

(a) $\frac{L}{4}$ (b) $\frac{L}{2}$
(c) L (d) 2L

J&K-CET-2015

Ans. (d) : Angular momentum during uniform circular motion

$$L = mvr \qquad ....(i)$$

$$\text{Kinetic energy } K = \frac{1}{2}mv^2$$

$$K = \frac{1}{2}m \times \left(\frac{L}{mr}\right)^2 \qquad \left[\text{from eq}^n \text{ (i)}\right]$$

$$K = \frac{L^2}{2mr^2} \qquad ....(ii)$$

According to question-

$$K' = \frac{(L')^2}{2mr^2} = 4K$$

$$\frac{(L')^2}{2mr^2} = \frac{4 \times L^2}{2mr^2} \qquad [\text{from eq}^n \text{ (ii)}]$$

$$L' = 2L$$

379. If the torque is zero, what will be the value of angular momentum?

(a) Constant in magnitude but changing in direction
(b) Changing in magnitude but constant in direction
(c) Constant in both magnitude and direction
(d) zero

UPSEE - 2004

Ans. (c) : If the torque is zero then angular momentum constant in both magnitude and direction.

380. In a planetary motion, the areal velocity of position vector of a planet depends on angular velocity (ω) and distance (r) of the planet from the sun. The correct relation for areal velocity $\left(\frac{dA}{dt}\right)$ is

(a) $\frac{dA}{dt} \propto \omega r$ (b) $\frac{dA}{dt} \propto \omega^2 r$
(c) $\frac{dA}{dt} \propto \omega r^2$ (d) $\frac{dA}{dt} \propto \sqrt{\omega r}$

Manipal UGET-2016

Ans. (c): Area velocity $\frac{dA}{dt} \propto \omega^x.r^y$

According to the principal of homogeneity of dimensions.

$$\frac{dA}{dt} = \left[M^0L^2T^{-1}\right],\ \omega = \left[M^0L^0T^{-1}\right] \text{ and } r = \left[M^0LT^0\right]$$

$$\left[M^0L^2T^{-1}\right] = \left[M^0L^0T^{-1}\right]^x \times \left[M^0LT^0\right]^y$$

$$\left[M^0L^2T^{-1}\right] = \left[M^0L^0T^{-x}\right] \times \left[M^0L^yT^0\right]$$

For L,

$$2 = 0 + y \Rightarrow 2 = y$$

For T,

$$-1 = -x + 0 \Rightarrow x = 1$$

$$\frac{dA}{dt} \propto \omega^x.r^y$$

$$\frac{dA}{dt} \propto \omega r^2$$

381. A satellite of mass m is circulating around the earth with constant angular velocity. If the radius is R_0 and mass of earth is M, then the angular momentum about the centre of the earth is

(a) $m \times \sqrt{GM/R_0}$ (b) $M \times \sqrt{GmR_0}$
(c) $m \times \sqrt{GMR_0}$ (d) $M \times \sqrt{GM/R_0}$

UP CPMT-2013

Ans. (c) : Angular momentum (L) = mvR_0
Where, m = mass of satellite

$$v \text{ (orbital velocity)} = \sqrt{\frac{GM}{R_0}}$$

R_0 = Radius

Then, $$L = m \times \sqrt{\frac{GM}{R_0}} \times R_0$$

$$L = m \times \sqrt{GMR_0}$$

382. The distance between the sun and the earth be r, then the angular momentum of the earth around the sun is proportional to

(a) $\sqrt{r}$ (b) $r^{3/2}$
(c) r (d) None of these

UP CPMT-2012

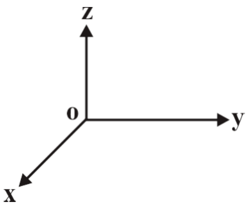
@apna_pdf

Ans. (a) : We know that for an orbit, angular momentum is conserved and this leads to one of Kepler's law. For a circular orbit angular momentum is

$$L = mvr = m\sqrt{\frac{GM}{r}}\,r \quad = m\sqrt{GMr}$$

$$\boxed{L \propto \sqrt{r}}$$

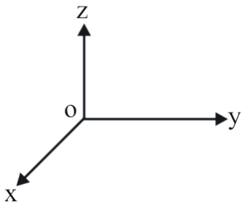
383. A force of $-F\hat{k}$ acts on O, the origin of the coordinate system. The torque about the point (1, – 1) is



(a) F (i – j)
(b) – F (i + j)
(c) F (i + j)
(d) – F(i – j)

UP CPMT-2008
JIPMER-2009

Ans. (c) : Given, $\vec{F} = -F\hat{k}$, $\vec{r} = (\hat{i} - \hat{j})$



Torque, $\tau = \vec{F}\times\vec{r} = (\hat{i}-\hat{j})\times(-F\hat{k})$

$$= -F(\hat{i}\times\hat{k} - \hat{j}\times\hat{k})$$

$$= F\left[(-\hat{i}\times\hat{k}) + (\hat{j}\times\hat{k})\right]$$

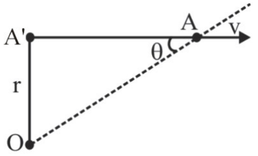
$$\tau = F(\hat{i}+\hat{j})$$

384. A particle moves in a straight line with constant acceleration. Its angular momentum about any fixed point is:

(a) constant
(b) directly proportional to time
(c) inversely proportional to time
(d) inversely proportional to distance covered

SRM JEE - 2007

Ans. (b) : Let a particle A of mass m is moving in a straight line with velocity v as shown below.



Angular momentum of particle about any fixed point say O will be

$$L = m(\overrightarrow{OA'}\times\vec{v})$$

$$L = mv(OA\sin\theta) = mvr$$

$$L = m(at)r$$

$$L = (mar)t \qquad \left[\begin{array}{l}\theta = 90^\circ, u = 0 \text{ and } v = at\\ a = \text{constant acceleration}\end{array}\right]$$

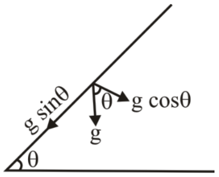
$$\therefore L \propto t$$

385. A spherical body of mass m and radius r is released from rest along a smooth inclined plane of inclination θ. The angular momentum of the body about the instantaneous point of contact after a time 't' from the instant of release is

(a) mgrt cosθ
(b) mgrt sinθ
(c) $\frac{3}{2}$mgrt sinθ
(d) None of these

SRM JEE - 2008

Ans. (b) : The component of acceleration of the body after time t is shown below



Component of acceleration along the place is gsinθ and perpendicular to the plane is gcosθ.

Velocity of the body after time t will be

$$v = u + at = gt\sin\theta \qquad [\because u = 0]$$

Now, angular momentum of the particle is

$$L = mvr = m(gt\sin\theta)r$$

$$L = mgrt\sin\theta$$

386. The motion of planets in the solar system is an example of conservation of

(a) mass
(b) momentum
(c) angular momentum
(d) kinetic energy

SRM JEE - 2012

Ans. (c) : External torque acting on a body is

$$\tau_{ext} = \frac{dL}{dt} \qquad [L = \text{angular momentum}]$$

For the given planets in solar system, $\tau_{ext} = 0$

$$\frac{dL}{dt} = 0 \Rightarrow L = \text{constant}$$

387. A wheel has moment of inertia 5×10^{-3} kg-m^2 and is making 20 rev/s. The torque needed to stop it in 10 s is ________ N m.

(a) $2\pi \times 10^{-2}$
(b) $2.5\pi \times 10^{-2}$
(c) $4\pi \times 10^{-2}$
(d) $4.5\pi \times 10^{-2}$

SRM JEE - 2013

Ans. (a) : Here, I = 5×10^{-3} kg-m^2, n = 20 rev/s

t = 10 s

Torque, $\tau = I\alpha$ (α = angular acceleration)

$$\tau = \frac{I\omega}{t} \qquad \left(\because \omega_f = 0 \;\therefore \alpha = \frac{\omega}{t}\right)$$

$$\tau = \frac{I(2\pi\upsilon)}{t} = \frac{2\pi\times5\times10^{-3}\times20}{10}\text{Nm}$$

$$\tau = 2\pi\times10^{-2}\,\text{Nm}$$

@apna_pdf

388. Torque per unit moment of inertia is equal to

(a) angular velocity (b) angular acceleration
(c) radius of gyration (d) inertia

SRMJEE - 2015

Ans. (b) : Torque is defined as

$$\tau = I\alpha \Rightarrow \alpha = \frac{\tau}{I}$$

Here, I = moment of inertia
α = angular acceleration

389. A turbine fan in a jet engine has moment of inertia 2.5 kgm^2 about its axis of rotation. Its angular velocity is 40t^2. The net torque is

(a) 100 t (b) 100 t^2
(c) 200 t (d) 200 t^2

SRMJEE - 2016

Ans. (c) : Given, moment of inertia (I) = 2.5 kg m^2
angular velocity (ω) = 40t^2
Torque is given by,

$$\tau = \frac{dL}{dt} = \frac{d(I\omega)}{dt} \qquad [\because L = I\omega]$$

$$\tau = \frac{Id\omega}{dt} = 2.5\frac{d}{dt}(40t^2) \qquad \left(\frac{dI}{dt} = 0\right)$$

$$\tau = 2.5 \times 80t = 200t$$

390. The torque on a body is zero. Which of the following should not change?

(a) Linear velocity
(b) Angular velocity
(c) Force acting on the body
(d) Angular displacement

MP PET-2012

Ans. (b) : When the torque acting upon a system is zero the angular momentum is constant and hence it is conserved.
We know that,
Angular momentum (L) = Iω
Where I is moment of inertia
ω = angular velocity
When L is constant ω is also constant.

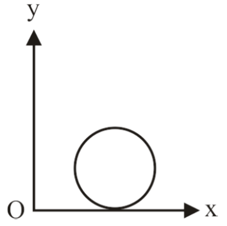
391. If applied torque on a system is zero, i.e., τ = 0, then for that system

(a) $\omega = 0$ (b) $\alpha = 0$
(c) $J = 0$ (d) $F = 0$

JIPMER-2014

Ans. (b) : Torque :- It is the twisting force that tends to cause rotation. Torque is a physical quantity, similar as force that causes the rotational motion.
$\text{Torque}(\tau) = I\alpha$
I = Moment of Inertia
α = Angular acceleration
$\tau = I\alpha$
According to question, $\tau = 0$
$I\alpha = 0$
As we know, $I \neq 0$
Hence, $\alpha = 0$

392. A disc of mass M and radius R is rolling with angular speed ω on a horizontal surface as shown in figure. The magnitude of angular momentum of the disc about the origin O is (here v is the linear velocity of the disc)



(a) $\frac{3}{2}MR^2\omega^2$ (b) $MR^2\omega$

(c) MRv (d) $\frac{3}{2}MR^2\omega$

AMU-2016

Ans. (d): Given,
Mass = M
Radius = R
Angular velocity = ω
We know that,

$$\text{Angular momentum (L)} = \vec{R} \times \vec{P}$$

$$= \left(\vec{R} \times \vec{V}\right)m$$

$$L = MvR \qquad (\sin 90^\circ = 1)$$

Then,
Magnitude of angular momentum of disk about the origin O is –

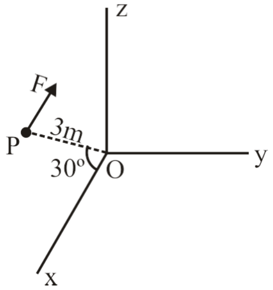
$$L_o = I\omega + MRv$$

$$= \frac{1}{2}MR^2\omega + MRv \qquad (\text{for disc } I = \frac{1}{2}MR^2)$$

$$= \frac{1}{2}MR^2\omega + MR(R\omega)$$

$$L_o = \frac{3}{2}MR^2\omega$$

393. A force F = 2.0 N acts on a particle P in the x-z plane. The force F is parallel to x-axis. The particle P (as shown in the figure) is at distance 3m and the line joining P with the origin makes angle 30° with the x-axis. The magnitude of torque on P with respect to origin O (in N-m) is



(a) 2 (b) 3
(c) 4 (d) 5

AMU-2012

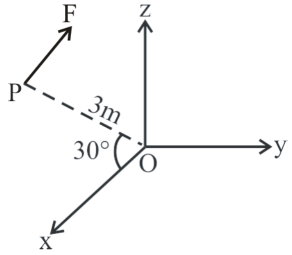
@apna_pdf

Ans. (b) : Given that,

Force (F) = 2.0 N

Distance (r) = 3m

Angle (θ) = 30°



According to figure,

Torque (τ) = F×r = Frsin θ

$$\tau = 2 \times 3 \times \sin 30° = 2\times3\times\frac{1}{2}$$

$$\tau = 3 \text{ N-m}$$

394. The position of a particle is given by $\vec{r} = \hat{i} + 2\hat{j} - \hat{k}$ momentum $\vec{p} = 3\hat{i} + 4\hat{j} - 2\hat{k}$. The angular momentum is perpendicular to

(a) x-axis

(b) y-axis

(c) z-axis

(d) Line at equal angles to all the three axes

EAMCET-1998

Ans. (a) : Given,

$$\vec{r} = \hat{i} + 2\hat{j} - \hat{k}$$

$$\vec{p} = 3\hat{i} + 4\hat{j} - 2\hat{k}$$

Angular momentum, $\vec{L} = \vec{r} \times \vec{p}$

$$\vec{L} = (\hat{i} + 2\hat{j} - \hat{k}) \times (3\hat{i} + 4\hat{j} - 2\hat{k})$$

$$= \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & -1 \\ 3 & 4 & -2 \end{bmatrix}$$

$$= \hat{i}[-4+4] - \hat{j}[-2+3] + \hat{k}(4-6)$$

$$= 0\hat{i} - \hat{j} - 2\hat{k}$$

$$\vec{L} = 0\hat{i} - \hat{j} - 2\hat{k}$$

Here in vector format is not present in equation then we say $[0\hat{i} - \hat{j} - 2\hat{k}]$ is perpendicular to x-axis.

395. A thin metal disc of radius 0.25 m and mass 2 kg starts from rest and rolls down an inclined plane. If its rotational kinetic energy is 4 J at the foot of the inclined plane, then its linear velocity at the same point is

(a) 1.2 ms^{-1}

(b) $2\sqrt{2}$ ms^{-1}

(c) 20 ms^{-1}

(d) 2 ms^{-1}

EAMCET-1997

Ans. (b) : Given that,

Radius (r) = 0.25 m,

Mass (m) = 2 kg

$$\text{Rotational K.E.} = \frac{1}{2}I\omega^2 = 4 \text{ J}$$

For disc moment of inertia $I = \frac{1}{2}mr^2$

$$\Rightarrow \frac{1}{2}\times\frac{1}{2}mr^2\left(\frac{v}{r}\right)^2 = 4\text{J} \qquad \begin{pmatrix} \because v = r\omega \\ \omega = \dfrac{v}{r} \end{pmatrix}$$

$$\Rightarrow \frac{1}{2}\times\frac{1}{2}\times2\times(0.25)^2\times\frac{v^2}{(0.25)^2} = 4$$

$$v^2 = 8$$

$$v = 2\sqrt{2} \text{ m/s}$$

396. A uniform metal rod of length L and mass M is rotating about an axis passing through one of the ends and perpendicular to the rod with angular speed ω. If the temperature increases by t°C, then the change in its angular velocity is proportional to which of the following? (coefficient of linear expansion of rod = α)

(a) $\sqrt{\omega}$

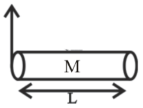
(b) ω

(c) ω^2

(d) $\frac{1}{\omega}$

EAMCET-2001

Ans. (b) : We know that, moment of inertia,



$$I = \frac{1}{3}ML^2$$

Length of the rod after t°C increment in temperature, L' = L (1+α t) {α= Coefficient of linear expansion}

Now, $I' = \frac{1}{3}ML^2(1+\alpha t)^2$

Now, from the law of conservation of angular momentum,

$$I\omega = I'\omega'$$

$$\frac{1}{3}ML^2\omega = \frac{1}{3}ML^2(1+\alpha t)^2\omega'$$

$$\frac{\omega'}{\omega} = \frac{1}{(1+\alpha t)^2}$$

{Let, k is constant}

Now, for a given value at t, $(1+\alpha t)^{-2}$ is constant k.

$$\therefore \frac{\omega'}{\omega} = k$$

$$\frac{\omega' - \omega}{\omega} = k - 1$$

$$\omega' - \omega = (k-1)\,\omega$$

$$\omega' - \omega \propto \omega$$

Change in angular velocity is proportional to ω

@apna_pdf

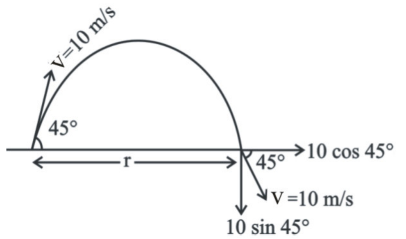
397. **A particle of mass 1 kg is projected with an initial velocity 10 ms^{-1} at an angle of projection 45° with the horizontal. The average torque acting on the projectile, between the time at which it is projected and the time at which it strikes the ground, about the point of projection in newton-metre is**

(a) 25 (b) 50

(c) 75 (d) 100

EAMCET-2004

Ans. (b) : According to Question we draw the parabolic equation.



Momentum, L = $\vec{r} \times \vec{p}$

$= r \times mv$

$$\tau = \frac{dL}{dt} = \frac{mvr}{t}$$

$$= \frac{1 \times 10 \sin 45^\circ \times 10 \cos 45^\circ \times t}{t}$$

Torque, $\tau = \frac{10}{\sqrt{2}} \times \frac{10}{\sqrt{2}} = \frac{100}{\sqrt{4}} = \frac{100}{2}$

$\tau = 50\,\text{Nm}$

398. **If torque is zero then:**

(a) angular momentum is conserved

(b) linear momentum is conserved

(c) energy is conserved

(d) angular momentum is not conserved

BCECE-2004

Ans. (a) : Given,

Torque (τ) = 0

We know that,

Torque $(\tau) = \frac{dL}{dt}$

Where dL = Change in angular momentum

Now,

$$\frac{dL}{dt} = 0 \qquad [\because \tau = 0]$$

$\therefore$ L = constant

Hence, angular momentum (L) is conserved.

399. **If there is change of angular momentum from 1J to 5 J in 5 s, then the torque is :**

(a) $\frac{3J}{5}$ (b) $\frac{4J}{5}$

(c) $\frac{5J}{4}$ (d) none of these

BCECE-2003

Ans. (b) : Given,

Initial angular momentum = 1J

Final angular momentum = 5J

Time (t) = 5sec

We know,

$$\text{Torque}(\tau) = \frac{\text{Change in angular momentum}}{\text{time taken}}$$

$$\tau = \frac{\Delta L}{\Delta t} = \frac{5-1}{5} = \frac{4}{5}\,J$$

400. **A fly-wheel of mass 25 kg has a radius of 0.2 m. It is making 240 rpm. What is the torque necessary to bring to rest in 20 s?**

(a) 2π Nm (b) 0.4π Nm

(c) $\frac{2}{\pi}$Nm (d) 4π Nm

AP EAMCET -2010

Ans. (b) : Given,

Mass (m) = 25 kg

Radius (r) = 0.2 m

Time (t) = 20 sec

Angular frequency (f) = 240 rpm = $\frac{240}{60}$rps

= 4 rps

We know that,

Angular velocity (ω_0) = 2πf

= 2π × 4

= 8π rad/ sec

$\omega = \omega_0 + \alpha t \qquad (\because \omega = 0)$

$0 = 8\pi + \alpha \times 20$

$\alpha = \frac{-8\pi}{20} = \frac{-2\pi}{5} \text{rad/s}^2$

$|\alpha| = \frac{2\pi}{5} \text{rad/s}^2$

And,

$I = mr^2 = 25 \times (0.2)^2$

$= 25 \times 0.04 = 1\,\text{kg m}^2$

We know that,

Torque $(\tau) = I\alpha$

$= 1 \times \frac{2\pi}{5} = \frac{2\pi}{5} = 0.4\pi$ Nm

$\tau = 0.4\pi$ Nm

401. **A particle of mass m = 5 units is moving with uniform speed v = 3$\sqrt{2}$ units in the XY-plane along the line Y = X + 4. The magnitude of the angular momentum about origin is**

(a) zero (b) 60 units

(c) 7.5 units (d) 40 units

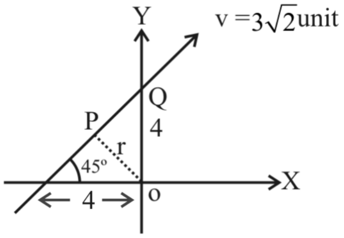
AP EAMCET -2015

AI PMT - 1991

@apna_pdf

Ans. (b) : Given,
Mass (m) = 5 unit
Uniform speed (v) = $3\sqrt{2}$ units
Equation of line–

$$Y = X + 4$$



We Know that,
Angular momentum (L) = mvr

$$L = 5 \times 3\sqrt{2} \times 4 \sin 45^\circ$$

$$L = 5 \times 3\sqrt{2} \times \frac{1}{\sqrt{2}} \times 4$$

$$L = 60 \text{ Units}$$

402. Choose the correct statement/statements from the following.

S1: The angular momentum of a body is always constant.

S2: The directions of the angular momentum vector and the angular velocity vector are always same.

S3: The direction of torque vector is always along the direction of change in angular momentum vector.

(a) S1 and S2 (b) S2 and S3
(c) S1 only (c) S3 only

AMU-2008

Ans. (a) : In a given system, unless an external torque is acting, there is conservation of angular momentum. Assuming that there is not external torque, angular momentum is conserved.

The angular momentum is Iω where I is about the axis of rotation. The angular momentum vector and angular velocity vector are in the same direction.

403. A particle performing uniform circular motion has angular momentum L. If its angular frequency is doubled and its kinetic energy halved, then angular momentum is

(a) $\frac{L}{4}$ (b) 2L
(c) 4L (d) $\frac{L}{2}$

AMU-2015

Ans. (a) : Given,
Angular momentum = L
Angular frequency = n
Angular velocity (ω) = 2πn
Kinetic energy = K
According to the question,
Angular momentum = L'
Angular frequency (n') = 2n
Angular velocity (ω') = 2π(2n)
Kinetic energy (K') = $\frac{K}{2}$

$$\omega' = 2\omega$$

We know that,

$$\text{Angular Momentum (L)} = I\,\omega \;\ldots\ldots \text{(i)}$$

And Kinetic energy (K) = $\frac{1}{2}I\omega^2$

$$I = \frac{2K}{\omega^2}$$

Putting the value of I in equation (i),

$$L = \frac{2K}{\omega^2} \times \omega$$

$$L = \frac{2K}{\omega}$$

Where ω' = 2ω and K' = $\frac{K}{2}$,

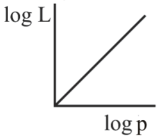
$$L' = \frac{2K'}{\omega'}$$

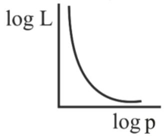
$$L' = \frac{2 \times \frac{K}{2}}{2\omega}$$

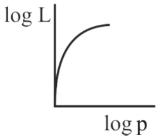
$$L' = \frac{K}{2\omega} = \frac{1}{4} \times \left(\frac{2K}{\omega}\right) \quad \text{(Multiply and divide by 2)}$$

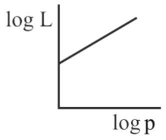
$$L' = \frac{L}{4} \quad \left(\because L = \frac{2K}{\omega}\right)$$

404. Angular momentum L is given by L = p.r. The variation of log L and log p is shown by

(i)


(ii)


(iii)


(iv)


(a) (i) (b) (ii)
(c) (iii) (d) (iv)

AMU-2013

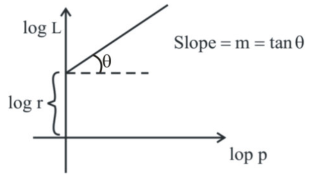
Ans. (d) : Given,

$$L = p.\,r$$

Taking log on both side, we get

$$\log L = \log p + \log r$$

$$y = mx + c$$



@apna_pdf

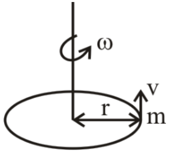
405. The angular momentum of a body with mass (m) moment of inertia (I) and angular velocity (ω) rad/s is equal to

(a) $I\omega$ (b) $I\omega^2$

(c) $\frac{I}{\omega}$ (d) $\frac{I}{\omega^2}$

AIPMT- 1996

Ans. (a) : According to question,



Now,

Angular momentum $(\vec{L}) = m(\vec{r} \times \vec{v})$

$$L = mrv \times \frac{r}{r}$$

$$L = mr^2 \times \frac{v}{r} \qquad \left[\because \omega = \frac{v}{r}\right]$$

$$L = I\omega$$

406. Angular momentum is

(a) vector (axial) (b) vector (polar)

(c) scalar (d) None of these

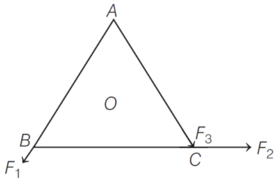
AIPMT- 1994

Ans. (a) : Since, angular momentum is the change of angular displacement and is vector quantity.

Axial vector is a vector which has rotational effect and act along the axis of rotation. Axial vector direction depends on the direction on rotation.

So, angular momentum is an axial vector.

407. O is the centre of an equilateral ΔABC. F_1, F_2 and F_3 are three forces acting along the sides AB, BC and AC as shown in figure. What should be the magnitude of F_3 ,so that the total torque about O is zero?

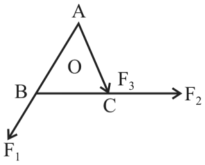


(a) $\frac{(F_1 + F_2)}{2}$ (b) $(F_1 - F_2)$

(c) $(F_1 + F_2)$ (d) $2(F_1 + F_2)$

AIPMT-1998

Ans. (c) :



According to vector's law of addition,

$$F_1 + F_2 - F_3 = 0$$

Then,

$$F_3 = F_1 + F_2$$

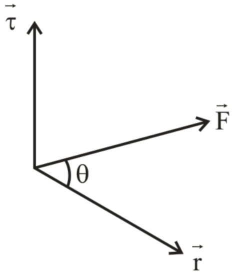
408. If F is the force acting on a particle having position vector r and τ be the torque of this force about the origin, then

(a) $r.\tau \neq 0$ and $F.\tau = 0$ (b) $r.\tau > 0$ and $F.\tau < 0$

(c) $r.\tau = 0$ and $F.\tau = 0$ (d) $r.\tau = 0$ and $F.\tau \neq 0$

AIPMT-2009

Ans. (c) : Suppose that



We know that,

$$\vec{\tau} = \vec{r} \times \vec{F}$$

Angle between $\vec{\tau}$ and $\vec{r}$ or $\vec{\tau}$ and $\vec{F}$ is equal to 90° .

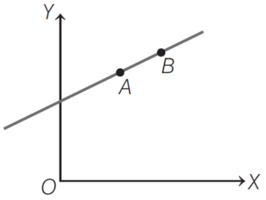
So, their Dot product is zero.

Then,

$$r.\tau = 0$$

And, $F.\tau = 0$

409. A particle of mass m in the XY-plane with a velocity v along the straight line AB. If the angular momentum of the particle with respect to origin O is L_A when it is at A and L_B when it is at B, then



(a) $L_A > L_B$

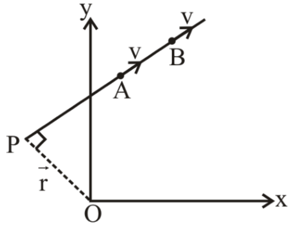
(b) $L_A = L_B$

(c) the relationship between L_A and L_B depends upon the slope of the line AB

(d) $L_A > L_B$

AIPMT-2007
AIIMS-2007

Ans. (b) : According to question,



Now,

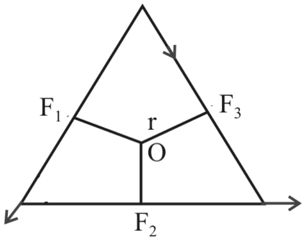
Angular momentum $(\vec{L}) = m(\vec{r} \times \vec{v})$

For both position A and B – $\vec{r}$, $\vec{v}$ and m is same.

Thus, $\vec{L}_A = \vec{L}_B$

@apna_pdf

410. ABC is an equilateral triangle with O as its centre. F_1, F_2 and F_3 represent three forces acting along the sides AB, BC and AC, respectively. If the total torque about O is zero, then the magnitude of F_3 is



(a) $F_1 + F_2$
(b) $F_1 + F_2$
(c) $\frac{F_1 + F_2}{2}$
(d) $2(F_1 + F_2)$

AIPMT 2012

Ans. (a) : According to question,
Net torque about point O,

$$\tau = \tau_{F_1} + \tau_{F_2} + \tau_{F_3}$$

The torque F_1r and F_2r of F_1 and F_2 are anti-clockwise.
The torque F_3r of F_3 is clockwise.

$$F_1r + F_2r - F_3r = \tau$$

For Net torque to be zero,

$$F_1r + F_2r = F_3r$$
$$F_3 = F_1 + F_2$$

411. The instantaneous angular position of a point on a rotating wheel is given by the equation θ (t) = $2t^3 - 6t^2$. The torque on the wheel becomes zero at

(a) t = 0.5 s
(b) t = 0.25 s
(c) t = 2s
(d) t = 1s

AIPMT- 2011

Ans. (d) : Given that,

$$\theta(t) = 2t^3 - 6t^2$$

We know,

$$\omega = \frac{d[\theta\ (t)]}{dt}$$
$$\omega = \frac{d}{dt}\left(2t^3 - 6t^2\right)$$
$$\omega = 6t^2 - 12t$$

Now,

Angular momentum (L) = Iω

Since,

$$\text{Torque } (\tau) = \frac{dL}{dt}$$
$$\tau = I\frac{d\omega}{dt}$$
$$\tau = I\frac{d}{dt}\left(6t^2 - 12t\right)$$
$$\tau = I\,(12t - 12)$$

When torque is zero,

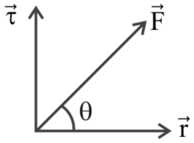
$$0 = I\,(12t - 12)$$
$$t = 1\text{ s}$$

412. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along

(a) a line perpendicular to the plane of rotation
(b) the line making an angle of 45° to the plane of rotation
(c) the radius
(d) the tangent to the orbit

AIPMT- 2012

Ans. (a) :



We know,

$$\vec{\tau} = \vec{r} \times \vec{F}$$

Torque is axial vector. So, its direction is always perpendicular to plane of motion.

413. A force $\mathbf{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\mathbf{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of α for which angular momentum about origin is conserved is

(a) −1
(b) 2
(c) zero
(d) 1

AIPMT- 2014

Ans. (a) : Given that,

$$\text{Force } \left(\vec{F}\right) = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$$
$$\text{Position } \left(\vec{r}\right) = 2\hat{i} - 6\hat{j} - 12\hat{k}$$

Angular momentum about origin is constant.
Then,

$$\hat{r} \times \hat{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -6 & -12 \\ \alpha & 3 & 6 \end{vmatrix}$$
$$0 = \hat{i}\ (-36+36) - \hat{j}\,(12+12\alpha) + \hat{k}\,(6+6\alpha)$$
$$\hat{j}\,(12\alpha+12) + \hat{k}\,(6+6\alpha) = 0$$

Then,

$$12\alpha + 12 = 0$$
$$\alpha = -1$$

414. An automobile moves on a road with a speed of 54 kmh^{-1}. The radius of its wheels is 0.45 m and the moment of inertia of the wheel about its axis of rotation is 3 kgm^2. If the vehicle is brought to rest in 15 s, the magnitude of average torque transmitted by its brakes to the wheel is

(a) 6.66 kg m^2 s^{-2}
(b) 8.58 kg m^2 s^{-2}
(c) 10.86 kg m^2 s^{-2}
(d) 2.86 kg m^2 s^{-2}

AIPMT- 2015

Ans. (a) : Given,

$$\text{Speed (v)} = 54\text{ km/h} = 54 \times \frac{5}{18} = 15\text{ m/sec}$$

Radius (r) = 0.45m

@apna_pdf

Moment of inertia (I) = 3 kgm^2

Time to stop (t) = 15 second

We know,

$$v = r\omega$$

$$\omega = \frac{v}{r} = \frac{15}{0.45}$$

$$\omega = \frac{100}{3}\,\text{rad/sec}$$

From equation of motion,

$$\omega = \omega_0 + \alpha t$$

$$0 = \frac{100}{3} + \alpha \times 15$$

$$\alpha = \frac{100}{45}\,\text{rad/sec}^2$$

We also know,

$$\tau = I\alpha = 3 \times \frac{100}{45} = \frac{100}{15} = 6.66\text{ kg m}^2\text{s}^{-2}$$

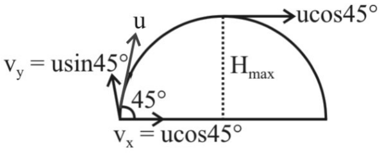
415. A body of mass 5 kg is projected with a velocity 'u' at an angle 45° to the horizontal. The magnitude of angular momentum of the body when it is at the highest position with respect to the point of projection is :

(a) $\frac{u^3}{5\sqrt{5}g}$ (b) $\frac{5u^3}{4\sqrt{2}g}$

(c) $\frac{u^3}{5g}$ (d) $\frac{u^3}{\sqrt{5}g}$

AP EAMCET(Medical)-2015

Ans. (b) : Given that,



We have,

$$H = \frac{u^2\sin^2\theta}{2g}$$

$$H_{max} = \frac{u^2\sin^2 45°}{2g}$$

$$H_{max} = \frac{u^2}{4g}$$

Now,

Angular momentum $\left(\vec{L}\right) = m\left(\vec{r} \times \vec{u}\right)$

$L = mur\cos45°$ [Here, $r = H_{max}$]

$$L = 5 \times u\,\frac{u^2}{4g}\,\frac{1}{\sqrt{2}}$$

$$= \frac{5u^3}{4\sqrt{2}g}$$

416. A mass is whirled in a circular path with a constant angular velocity and its angular momentum is L. If the string is now halved, keeping the angular velocity same, the angular momentum is:

(a) $\frac{L}{4}$ (b) $\frac{L}{2}$

(c) L (d) 3L

AP EAMCET(Medical)-2001

Ans. (a) : We know,

Angular momentum (L) = mvr

$$L = mr^2\,\omega \qquad (\because v = r\omega)$$

When $r' = \frac{r}{2}$,

$$L' = m(r')^2\omega = \frac{mr^2\omega}{4}$$

Hence, $L' = \frac{L}{4}$

417. Consider the following statements:

If the net external torque acting on an object is switched off, then

1. linear momentum will remain unchanged

2. angular momentum will remain unchanged

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

NDA (II) 2008

Ans. (b) : We know,

$$\tau = \frac{dL}{dt}$$

If $\tau = 0$,

$$\frac{dL}{dt} = 0$$

L = constant

Thus, angular momentum will remain unchanged.

418. A disc of mass 2 kg and radius 0.2 m is rotating with angular velocity 30 rad/s. What is angular velocity, if a mass of 0.25 kg is put on periphery of the disc?

(a) 24 rad/s (b) 36 rad/s

(c) 15 rad/s (d) 26 rad/s

UPSEE - 2006

Ans. (a) : Given that,

M = 2kg, m = 0.25kg

r = 0.2 m, ω_1 = 30 rad/sec

If no external force act on a system then angular momentum will be constant.

$$I_1\omega_1 = I_2\omega_2$$

$$\frac{1}{2}Mr^2\omega_1 = \frac{1}{2}(M + 2m)r^2\omega_2$$

$$\frac{1}{2} \times 2 \times 0.2^2 \times 30 = \frac{1}{2} \times (2 + 2 \times 0.25) \times 0.2^2\,\omega_2$$

$$0.5 \times 2 \times 0.04 \times 30 = 0.5 \times 2.5 \times 0.04\omega_2$$

$$1.2 = 0.05\omega_2$$

$$\omega_2 = \frac{1.2}{0.05} = \frac{1200}{50}$$

ω_2 = 24 rad/sec.

@apna_pdf

419. Two discs are rotating about their axes, normal to the discs and passing through the centre's of the discs. Disc D_1 has 2 kg mass and 0.2 m radius and initial angular velocity of 50 rad s^{-1}.Disc D_2 has 4 kg mass, 0.1 m radius and initial angular velocity of 200 rad s^{-1}. The two discs are brought in contact face to face, with their axes of rotation coincident. The final angular velocity (in $rads^{-1}$) of the system is

(a) 60 (b) 100 (c) 120 (d) 40

COMEDK 2013

Ans. (b) : Given that,

$M_1 = 2kg$
$M_2 = 4$ kg
$r_1 = 0.2$ m
$r_2 = 0.1$ m
$\omega_1 = 50$ rad/sec
$\omega_2 = 200$ rad/sec

According to conservation` of angular momentum

$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\ \omega_f$

$$\frac{(M_1r_1^2)}{2}(\omega_1)+\frac{(M_2r_2^2)}{2}(\omega_2) = \left(\frac{M_1r_1^2}{2}+\frac{M_2r_2^2}{2}\right)\omega_f$$

$$\frac{2\times(0.2)^2}{2}\times 50+\frac{4\times(0.1)^2}{2}\times 200$$

$$=\left(\frac{2\times(0.2)^2}{2}+\frac{4\times(0.1)^2}{2}\right)\omega_f$$

$$(2+4)=\left(\frac{1}{25}+\frac{1}{50}\right)\omega_f$$

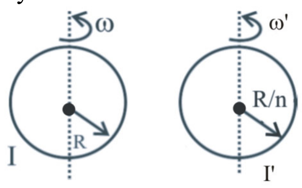
$\omega_f = 100\ rads^{-1}$

420. A solid sphere is rotating about a diameter at an angular velocity ω. If it cools so that its radius reduces to $\frac{1}{n}$ of its original value, its angular velocity becomes

(a) $\frac{\omega}{n}$ (b) $\frac{\omega}{n^2}$ (c) $n\omega$ (d) $n^2\omega$

UP CPMT-2005

Ans. (d) : Given,
Radius of 1st solid sphere = R
Angular velocity = ω
Radius of 2nd solid sphere = R/n
Angular velocity = ω′



According to conservation of angular momentum-

$L_i = L_f$
$I\omega = I'\omega'$

$$\frac{2}{5}MR^2\omega=\frac{2}{5}M\left(\frac{R}{n}\right)^2\omega'$$

$\omega' = n^2\omega$

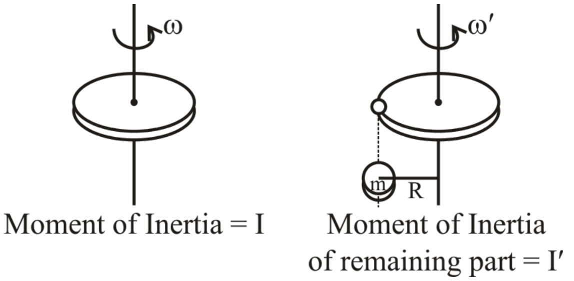
421. A circular disc of mass M and radius R is rotating with an angular velocity ω about an axis passing through its centre and perpendicular to the plane of the disc. A small point like part of mass m detaches from the rim of the disc and continues to move with same angular speed. The angular velocity of remaining disc just after detaching will become

(a) $\left(\frac{M-2m}{M+m}\right)\omega$ (b) $\left(\frac{M+2m}{M+m}\right)\omega$

(c) $\left(\frac{M-2m}{M-m}\right)\omega$ (d) $\left(\frac{M+2m}{M-m}\right)\omega$

UP CPMT-2002

Ans. (c) : By the law of conservation of angular momentum,



$I\omega = I'\omega'$

$$\frac{1}{2}MR^2\omega=\frac{1}{2}(M-m)R^2\omega'+mR^2\omega$$

$$\frac{1}{2}MR^2\omega-mR^2\omega=\frac{1}{2}(M-m)R^2\omega'$$

$$\left(\frac{M}{2}-m\right)R^2\omega=\frac{1}{2}(M-m)R^2\omega'$$

$$\left(\frac{M-2m}{2}\right)\omega=\frac{1}{2}(M-m)\omega'$$

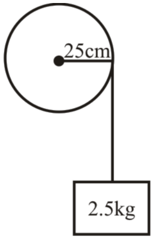
$$\omega'=\left(\frac{M-2m}{M-m}\right)\omega$$

422. A cord is wound over the rim of a flywheel of mass 20 kg and radius 25 cm. A mass 2.5 kg attached to the cord is allowed to fall under gravity. Calculate the angular acceleration of the fly wheel.

(a) 25 rad/s^2 (b) 20 rad/s^2
(c) 10 rad/s^2 (d) 5 rad/s^2

AMU-2012

Ans. (c) : Given that,
Flywheel mass (M) = 20 Kg
Radius (r) = 25 cm = 0.25 m
Mass (m) = 2.5 kg



@apna_pdf

We know that,

$$F = mg = 2.5 \times 10 = 25\,\text{N}$$

$$\text{Torque } (\tau) = F \times r = 25 \times 0.25 = 6.25\ \text{N}$$

$$\text{Moment of inertia for wheel} = \frac{1}{2}Mr^2$$

$$I = \frac{1}{2} \times 20 \times (0.25)^2$$

$$I = 0.625\ \text{kg-m}^2$$

$$\because \quad \tau = I\alpha$$

$$\alpha = \frac{\tau}{I}$$

$$\alpha = \frac{6.25}{0.625}$$

$$\alpha = 10\ \text{rad/sec}^2$$

423. A constant torque of 1000 N-m, turns a wheel of moment of inertia 200 kg-m^2 about an axis through its centre. Its angular velocity after 3s is, (in rad/s)

(a) 1
(b) 5
(c) 15
(d) 10

EAMCET-1997

Ans. (c) : Given,

Torque (τ) = 1000 Nm, Moment of inertia (I) = 200 kg-m^2, Time (t) = 3 s, Angular velocity (ω) = ?

Torque formula-

$$\tau = I\alpha$$

$$1000 = 200 \times \alpha$$

$$\alpha = 5\ \text{rad/s}^2$$

Also, we know,

$$\omega = \omega_0 + \alpha t$$

$$\omega = 0 + 5 \times 3 \qquad \{\because \omega_0 = 0\}$$

$$\omega = 15\ \text{rad/sec}$$

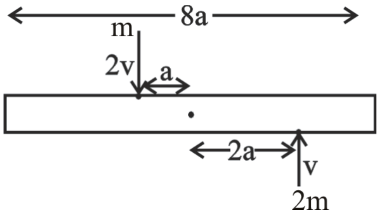
Hence, angular velocity of the wheel is 15 rad/s.

424. A uniform rod of length 8a and mass 6m lies on a smooth horizontal surface. Two point masses m and 2m moving in the same plane with speed 2v and v respectively strike the rod perpendicular at distance a and 2a from the mid point of the rod in the opposite directions and stick to the rod. The angular velocity of the system immediately after the collision is

(a) $\frac{6v}{32a}$
(b) $\frac{6v}{33a}$
(c) $\frac{6v}{40a}$
(d) $\frac{6v}{41a}$

EAMCET-2006

Ans. (d) :



Now, using the conservation of angular momentum about centre of mass of rod

$$2mva + 2mv.2a = I_f\omega$$

$$6\ mva = \left(ma^2 + 2m(2a)^2 + \frac{6m(8a)^2}{12}\right)\omega$$

$$6\ mva = (ma^2 + 8ma^2 + 32ma^2)\ \omega$$

$$6\ mva = (41ma^2)\ \omega$$

$$\omega = \frac{6v}{41a}$$

425. A solid sphere and a thin spherical shell of same radius rotate about their diameters with same angular momentum but with different angular velocities. If M$_1$ and M$_2$ are the masses of solid sphere and hollow sphere and if their angular velocities are in the ratio 1 : 2, then $\left(\frac{M_1}{M_2}\right)$ is

(a) $\frac{10}{3}$
(b) $\frac{5}{3}$
(c) $\frac{1}{3}$
(d) 3

TS EAMCET(Medical)-2015

Ans. (a) : Given,

Mass of solid sphere = M_1

Mass of hollow sphere = M_2

Angular velocity of solid sphere = ω_1

Angular velocity of hollow sphere = ω_2

We know that –

Angular momentum, L = Iω

For solid sphere moment of inertia (I_1) = $\frac{2}{5}M_1R^2$

For hollow sphere moment of inertia (I_2) = $\frac{2}{3}M_2R^2$

According to question-

$$I_1\omega_1 = I_2\omega_2$$

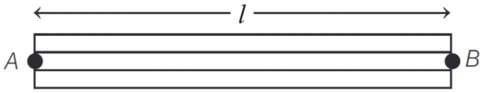
$$\frac{2}{5}M_1R^2\omega_1 = \frac{2}{3}M_2R^2\omega_2$$

$$\frac{M_1}{M_2} = \frac{5}{3}\frac{\omega_2}{\omega_1}$$

$$\frac{M_1}{M_2} = \frac{5}{3} \times 2 \qquad \left\{\because \frac{\omega_1}{\omega_2} = \frac{1}{2}\right\}$$

$$\frac{M_1}{M_2} = \frac{10}{3}$$

426. A uniform rod of length *l* and mass m is free to rotate in a vertical plane about A. The rod initially in horizontal position is released. The initial angular acceleration of the rod is (moment of inertia of rod about A is $\frac{ml^2}{3}$)



@apna_pdf

(a) $\frac{3g}{2l}$ (b) $\frac{2l}{3g}$

(c) $\frac{3g}{2l^2}$ (d) $mg\frac{l}{2}$

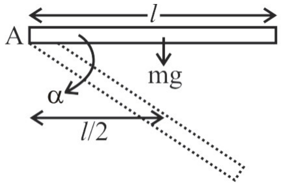
NEET- 2013

AIPMT-2007

Ans. (a) : Given, moment of inertia, $I=\frac{ml^2}{3}$

Where, l = rod of length, m = mass

Apply conservation of angular momentum theorem.



We know that,

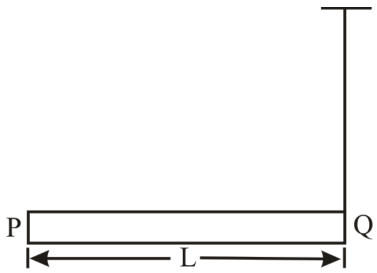
$$\tau = I\times\alpha \qquad \Rightarrow \left\{\tau = mg\frac{l}{2}\right\}$$

$$mg\frac{l}{2} = I\alpha$$

$$mg\frac{l}{2} = \frac{1}{3}ml^2\alpha$$

$$\alpha = \frac{3g}{2l}$$

427. A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a massless string tied to point Q as shown in the figure. When string is cut, the initial angular acceleration of the rod is



(a) $\frac{3g}{2L}$ (b) $\frac{g}{L}$

(c) $\frac{2g}{L}$ (d) $\frac{2g}{3L}$

MHT-CET 2013

Ans. (a) : Given that,

Mass of rod PQ = M

Length = L

Let angular acceleration of the rod = a

Now,

Torque acting on the rod

$$\tau = Mg\frac{L}{2} \qquad ....(i)$$

Moment of inertia of the rod about P,

$$I = \frac{ML^2}{3} \qquad ....(ii)$$

But, $\tau = I\alpha$

By putting the value of 'I' from equation (ii) we get,

$$\tau = \frac{ML^2}{3}\times\alpha \qquad ....(iii)$$

From equation (i) and (iii),

$$Mg\frac{L}{2} = \frac{ML^2}{3}\times\alpha$$

$$\alpha = \frac{3g}{2L}$$

Hence, angular acceleration of the rod is $\frac{3g}{2L}$

428. A solid cylinder of mass 20 kg rotates about its axis with angular speed 100 rad s^{-1}. The radius of the cylinder is 0.25 m. What is the kinetic energy associated with the rotation of cylinder? What is the magnitude of angular momentum of cylinder about its axis?

(a) 62.5 J-s (b) 70.4 J-s

(c) 79.6 J-s (d) 60.5 J-s

BCECE-2015

Ans. (a) : Given that,

Mass (m) = 20 kg

Radius of cylinder(R) = 0.25m

Angular speed (ω) = 100 rad s^{-1}

Moment of inertia of solid cylinder

$$I = \frac{mR^2}{2} = \frac{20\times(0.25)^2}{2} = 0.625\,kg.m^2$$

Kinetic energy of rotation-

$$K.E = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\times0.625\times(100)^2$$

$$= 3125\ J$$

Now, Angular momentum

$$L = I\omega$$

$$= 0.625\times100$$

$$L = 62.5\ Js.$$

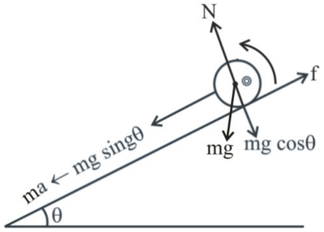
429. A disc and a sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first?

@apna_pdf

(a) Sphere
(b) Both reach at the same time
(c) Depends on their masses
(d) Disc

NEET- 2016

Ans. (a) :



For the object in an inclined plane, torque acting on it will be only due to friction.

Hence, $\tau = fR$

$f \rightarrow$ Friction of object

$R \rightarrow$ Radius of object

Let the moment of inertia is I. then angular acceleration will be-

$$\alpha = \frac{\tau}{I} \qquad (\because \tau = fR)$$

$$\alpha = \frac{fR}{I}$$

Acceleration along the incline will be

$$a = \frac{mg\sin\theta - f}{m} \quad \text{(equation of motion)}$$

For pure rolling of object

$$a = \alpha R$$

$$\frac{mg\sin\theta - f}{m} = \frac{fR \times R}{I}$$

$$\Rightarrow (mg\sin\theta - f)I = mfR^2$$

$$\Rightarrow mgI\sin\theta - fI = mfR^2$$

$$\Rightarrow mgI\sin\theta = \left(mR^2 + I\right)f$$

$$f = \frac{mgI\sin\theta}{\left(mR^2 + I\right)}$$

Therefore

$$a = \frac{mg\sin\theta - f}{m}$$

$$a = \frac{mg\sin\theta - \frac{mgI\sin\theta}{I + mR^2}}{m}$$

$$a = \frac{mg\sin\theta\left[1 - \frac{I}{I + mR^2}\right]}{m}$$

$$a = g\sin\theta\left(1 - \frac{I}{I + mR^2}\right)$$

$$a = g\sin\theta\frac{\left(I + mR^2 - I\right)}{\left(I + mR^2\right)}$$

$$a = g\sin\theta\left(\frac{mR^2}{I + mR^2}\right)$$

Relation between moment of Inertia and radius of gyration

$$I = mK^2$$

Then value of acceleration

$$a = \frac{g\sin\theta}{\left(1 + \frac{K^2}{R^2}\right)}$$

For disc, $\frac{K^2}{R^2} = \frac{1}{2} \Rightarrow 0.5$

for sphere, $\frac{K^2}{R^2} = \frac{2}{5} \Rightarrow 0.4$

Since the value of $\frac{K^2}{R^2}$ is smaller in sphere it means acceleration of sphere will be more therefore, the sphere will reach first.

430. A wheel of moment of inertia 2.5 kg-m^2 has an initial angular velocity of 40 rad.s^{-1}. A constant torque of 10 Nm acts on the wheel. The time during which the wheel is accelerated to 60 rad.s^{-1} is

(a) 4 s
(b) 6 s
(c) 5 s
(d) 2.5 s
(e) 4.5 s

Kerala CEE - 2009

Ans. (c) : Given that,

$\tau = 10$ Nm

$I = 2.5$ kg m^2

$\omega_u = 40$ rad/s

$\omega_v = 60$ rad/s

We know that,

$\tau = I\,\alpha$

$$\alpha = \frac{\tau}{I}$$

$$= \frac{10}{2.5}$$

$$= 4 \text{ rad/s}^2$$

Now, angular equation of motion -

$\omega_f = \omega_i + \alpha t$

$60 = 40 + 4t$

$20 = 4t$

$t = 5$ s

@apna_pdf

431. A thin circular ring of mass M and radius R is rotating about its axis with a constant angular velocity ω. Two objects, each of mass m, are connected gently to the ring. The ring now rotates with an angular velocity.

(a) $\frac{\omega M}{M+m}$ (b) $\frac{\omega(M-2m)}{(M+2m)}$

(c) $\omega\frac{(M+2m)}{M}$ (d) $\frac{\omega M}{M+2m}$

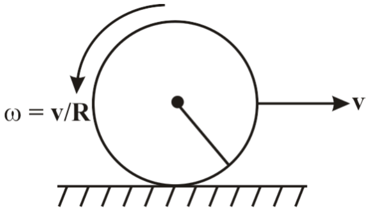
MP PMT-2009

Ans. (d) : Let, final angular velocity = ω_1.

Angular momentum is conserved about the centre of ring.

$$L_i = L_f$$
$$Mr^2\omega + 0 = Mr^2\omega_1 + 2mr^2\,\omega_1$$
$$Mr^2\omega = r^2\omega_1\,(M + 2m)$$
$$\omega_1 = \frac{M\omega}{M+2m}$$

432. A solid sphere is set into motion on a rough horizontal surface with a linear speed v in the forward direction and an angular speed $\frac{v}{R}$ in the anticlockwise direction as shown in figure. Find the linear speed of the sphere when it stops rotating and $\omega = \frac{v}{R}$.

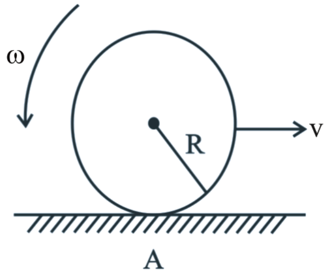


(a) $\frac{3v}{5}$ (b) $\frac{2v}{5}$

(c) $\frac{4v}{3}$ (d) $\frac{7v}{3}$

JIPMEER-2015

Ans. (a) : Given that, angular speed (ω) = $\frac{v}{r}$, linear speed = v



We take moment at A then external torque will be zero.

Initial angular momentum = Angular momentum after rotation stop

$$Mv \times R - I\omega = Mv_o \times R$$
$$MvR - \frac{2}{5}\times MR^2 \times \frac{v}{R} = Mv_oR$$
$$MvR - \frac{2}{5}MvR = Mv_oR$$
$$\frac{3MvR}{5} = Mv_oR$$
$$\boxed{v_o = \frac{3v}{5}}$$

433. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. Another disc of same thickness and radius but of mass $\frac{1}{8}$M is placed gently on the first disc co-axially. The angular velocity of the system is now

(a) $\frac{8}{9}\omega$ (b) $\frac{5}{9}\omega$

(c) $\frac{1}{3}\omega$ (d) $\frac{2}{9}\omega$

TS EAMCET (Engg.)-2016

Ans. (a) :

According to law of conservation of momentum

$$I_1\omega_1 = I_2\omega_2$$

But $I_2 = \frac{1}{2}MR^2 + \frac{1}{8}\left(\frac{MR^2}{2}\right)$

$$I_2 = \frac{8MR^2 + MR^2}{16} = \frac{9MR^2}{16}$$
$$\frac{1}{2}MR^2\omega = \frac{9}{16}MR^2\omega_2$$
$$\omega = \frac{9}{8}\omega_2$$
$$\omega_2 = \frac{8}{9}\omega$$

434. Assertion (A): A ball connected to a string is in circular motion on a frictionless horizontal table and is in equilibrium.

Reason (R) : Magnitude of the centripetal force is equal to the magnitude of the tension in the string.

The correct answer is

@apna_pdf

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(c) (A) is true but (R) is not true.
(d) (A) is not true but (R) is true.

AP EMCET(Medical)-2008

Ans. (b) :
In the circular motion, the direction of resultant force is towards centre.

The resultant force, $F = \frac{mv^2}{r}$

$$F = \frac{m(r\omega)^2}{r} \qquad (\because v = r\omega)$$

$$F = mr\omega^2$$

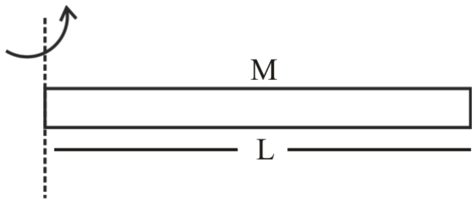
Thus a centripetal force of magnitude $\frac{mv^2}{r}$ is needed to keep the particle moving in circular path with the constant speed.
Hence, option (b) is correct.

435. A uniform cylindrical rod of mass M and length L is rotating with an angular velocity ω. The axis of rotation is perpendicular to its axis of symmetry and passes through one of its edge faces. If the room temperature increases by t and the coefficient of linear expansion of the rod is α, the magnitude of the change in its angular velocity is:

(a) $2\omega\alpha t$
(b) $\omega\alpha t$
(c) $\frac{3}{2}\omega\alpha t$
(d) $\frac{\omega\alpha t}{2}$

AP EAMCET(Medical)-2005

Ans. (a) :



Given,
Mass of rod = M and length of Rod = L
Moment of inertia of rod about the axis passing through its end, $I = \frac{ML^2}{3}$

As the room temperature is increased by t
Then,

$$L' = L(1 + \alpha t)$$

and $$I' = \frac{ML'^2}{3}$$

By conservation of angular momentum

$$I\omega = I'\omega'$$

$$\frac{ML^2}{3}.\omega = \frac{ML'^2}{3}.\omega'$$

$$L^2\omega = L^2(1 + \alpha t)^2.\omega'$$

$$\omega' = \omega(1 + \alpha t)^{-2}$$

By using binomial theorem-

$$\omega' = \omega(1 - 2\alpha t)$$

$$\omega' = \omega - 2\omega\alpha t$$

$$\omega - \omega' = 2\omega\alpha t$$

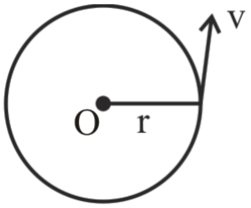
$$\Delta\omega = 2\omega\alpha t$$

436. A particle of mass m is rotating along a circular path of radius r. Its angular momentum L. The centripetal force acting on the particle is:

(a) $\frac{L^2}{mr}$
(b) $\frac{L^2 m}{r}$
(c) $\frac{L^2}{mr^2}$
(d) $\frac{L^2}{mr^3}$

AP EAMCET(Medical)-2002

Ans. (d) :



Angular momentum of a particle moving in a circular path (L) = mvr

$$v = \frac{L}{mr}$$

$\therefore$ Centripetal force $(F) = \frac{mv^2}{r}$

$$F = \frac{m}{r}\left(\frac{L}{mr}\right)^2 \qquad \left\{\because v = \frac{L}{mr}\right\}$$

$$F = \frac{L^2}{mr^3}$$

@apna_pdf

(d) Moment of Inertia, Radios of Gyration

437. If a solid sphere of mass 5kg and a disc of mass 4kg have the same radius. Then the ratio of moment of inertia of the disc about a tangent in its plane to the moment of inertia of the sphere about its tangent will be $\frac{x}{7}$. The value of x is ________.

JEE Main-25.01.2023, Shift-II

Ans. (5) : Given,

Mass of solid sphere (M_s) = 5 kg

Mass of disc (M_d) = 4 kg

Radius of solid sphere = Radius of disc = R

Ratio of moment of inertia of disc and sphere

$$\frac{I_d}{I_s} = \frac{x}{7}$$

Moment of inertia of solid sphere,

$$I_s = \frac{2}{5}M_sR^2 + M_sR^2$$

$$I_s = \frac{7}{5}M_sR^2$$

$$I_s = \frac{7}{5}\times 5R^2 = 7R^2 \qquad (\because M_s = 5\text{kg})$$

Moment of inertia of disc,

$$I_d = \frac{M_dR^2}{4} + M_dR^2$$

$$I_d = \frac{5}{4}M_dR^2$$

$$I_d = \frac{5}{4}\times 4R^2 = 5R^2 \qquad (\because M_d = 4\text{kg})$$

Then, ratio of moment of inertia,

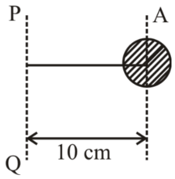
$$\frac{I_d}{I_s} = \frac{x}{7}$$

$$\frac{5R^2}{7R^2} = \frac{x}{7}$$

$$x = 5$$

So, value of x is 5.

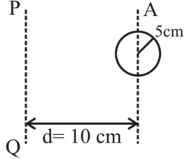
438. Solid sphere A is rotating about an axis PQ. If the radius of the sphere is 5 cm then its radius of gyration about PQ will be $\sqrt{x}$ cm. The value of x is ———.



JEE Main-24.01.2023, Shift-I

Ans. (110) : Given,

Sphere of radius (R) = 5 cm



$$I_{PQ} = I_{COM} + md^2$$

$$I_{PQ} = \frac{2}{5}MR^2 + Md^2 = M\left[\frac{2}{5}\times 5^2 + 10^2\right]$$

$$I_{PQ} = M\,[10 + 100] = 110\,M$$

For radius of gyration,

$$I_{PQ} = Mk^2$$

$$k^2 = \frac{I_{PQ}}{M} = \frac{110M}{M} = 110$$

$$k = \sqrt{110}\,\text{cm}$$

According to the question,

Radius gyration $(k) = \sqrt{x}$ cm

$$\sqrt{110} = \sqrt{x}\,\text{cm}$$

$$x = 110\text{ cm}$$

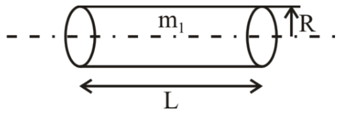
So, the value of x is 110 cm.

439. A uniform solid cylinder with radius R and length L has moment of inertia I_1, about the axis of the cylinder. A concentric solid cylinder of radius R' = R/2 and length L'=L/2 is carved out of the original cylinder. If I_2 is the moment of the inertia of the carved out portion of the cylinder then I_1/I_2 ......

(Both I_1 and I_2 are about the axis of the cylinder)

JEE Main-24.01.2023, Shift-II

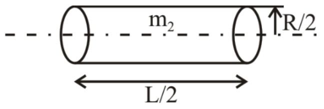
Ans. (32) : Case-I



$$\text{Moment of inertia } (I_1) = \frac{m_1R^2}{2} \qquad \left[\begin{aligned}\because m &= \rho V\\ &= \rho\pi R^2L\end{aligned}\right]$$

$$I_1 = \frac{\rho\pi R^2L\times R^2}{2} = \frac{\rho\pi R^4L}{2} \quad .....(i)$$

Case-II



Moment of inertia,

$$I_2 = \frac{m_2(R/2)^2}{2} = \frac{\rho\pi\left(\frac{R}{2}\right)^2\times\frac{L}{2}\times R^2}{8}$$

From equation (i), we get,

$$I_2 = \frac{1}{32}I_1$$

$$\therefore \quad \frac{I_1}{I_2} = 32$$

@apna_pdf

440. Two discs of same mass and different radii are made of different materials such that their thicknesses are 1 cm and 0.5 cm respectively. The densities of materials are in the ratio 3:5. The moment of inertia of these discs respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of x is______.

JEE Main-31.01.2023, Shift-II

Ans. (5) Given, mass of first disc = mass of second disc = m,
Thickness of first disc (t_1) = 1 cm
Thickness of second disc (t_2) = 0.5 cm

Ratio of densities of material of disc $\left(\frac{\rho_1}{\rho_2}\right)=\frac{3}{5}$

$$\left(\frac{I_1}{I_2}\right)=\frac{x}{6}$$

Ratio of moment of inertia about diameters
As we know,

$$\frac{I_1}{I_2}=\frac{\frac{mR_1^2}{4}}{\frac{mR_2^2}{4}}=\frac{R_1^2}{R_2^2}$$

As, mass of both disc is same,
So, $\rho_1\times\pi R_1^2\times t_1=\rho_2\times\pi R_2^2\times t_2$

$$\Rightarrow\quad \frac{\rho_1}{\rho_2}=\frac{R_2^2t_2}{R_1^2t_1}=0.5\frac{R_2^2}{R_1^2}=\frac{1}{2}\frac{R_2^2}{R_1^2}$$

$$\Rightarrow\quad \frac{\rho_1}{\rho_2}=\frac{1}{2}\times\frac{I_2}{I_1}$$

$$\Rightarrow\quad \frac{I_1}{I_2}=\frac{1}{2}\times\frac{\rho_2}{\rho_1}$$

$$\Rightarrow\quad \frac{I_1}{I_2}=\frac{1}{2}\times\frac{5}{3}\qquad\qquad\left(\frac{\rho_2}{\rho_1}=\frac{5}{3}\right)$$

$$\Rightarrow\quad \frac{I_1}{I_2}=\frac{5}{6}=\frac{x}{6}$$

So, the value of x = 5

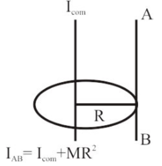
441. Moment of inertia of a disc of mass M and radius 'R' about any of its diameter is $\frac{MR^2}{4}$. The moment of inertia of this disc about an axis normal to the disc and passing through a point on its edge will be, $\frac{x}{2}$ MR². The value of x is ______

JEE Main-01.02.2023, Shift-II

Ans. (3) : Given, mass of disc = M, radius of disc = R

Moment of inertia about its any diameter = $\frac{MR^2}{4}$

By using parallel axis theorem –



Moment of inertia (I) = moment of inertia about an axis normal to disc + moment of inertia about a point passing through it edge

$$I=I_{CM}+MR^2$$

$$I=\frac{MR^2}{2}+MR^2=\frac{3}{2}MR^2=\frac{x}{2}MR^2$$

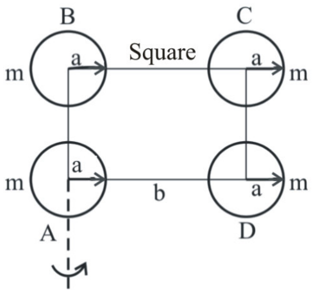
So, x = 3

442. Four spheres each of diameter '2a' and mass 'm' are placed in a way that their centers lie on the four comers of a square of side 'b'. Moment of inertia of the system about an axis along one of the sides of the square is——

(a) $\frac{8}{5}ma^2$
(b) $\frac{4}{5}ma^2+5mb^2$
(c) $\frac{4}{5}ma^2+2mb^2$
(d) $\frac{8}{5}ma^2+2mb^2$

AP EAMCET-12.07.2022, Shift-I
AP EAMCET-20.08.2021, Shift-I
AP EAMCET-06.09.2021, Shift-II
AMU - 2002

Ans. (d) : Given, diameter of each sphere = 2a
Mass of each sphere = m



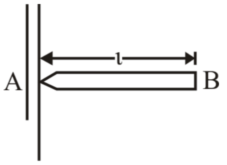
By using parallel axis theorem,

$$I_{net}=I_A+I_B+I_C+I_D$$

$$I_{net}=\frac{2}{5}ma^2+\frac{2}{5}ma^2+\frac{2}{5}ma^2+mb^2+\frac{2}{5}ma^2+mb^2$$

$$I_{net}=\frac{8}{5}ma^2+2mb^2$$

433. A uniform rod AB of length *l* and mass m is free to rotate about point A. The rod is released from rest in the horizontal position. Given that the moment of inertia of the rod about A is $\frac{ml^2}{3}$, the initial angular acceleration of the rod will be

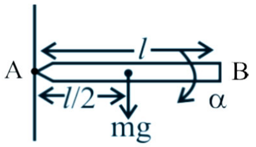


(a) $\frac{2g}{3\ell}$
(b) $mg\frac{\ell}{2}$
(c) $\frac{3}{2}g\ell$
(d) $\frac{3g}{2\ell}$

BITSAT-2017, NEET-2013
JCECE-2008, UP CPMT-2008
UPSEE - 2007, AIPMT-2007

@apna_pdf

Ans. (d) : Given, length of rod AB = l and mass = m



Moment of inertia of the rod about point

Torque acting on centre of gravity of rod,

$$\tau = I\times\alpha$$

$$mg\times\frac{l}{2} = \frac{ml^2}{3}\times\alpha$$

$$\therefore \quad \alpha = \frac{3g}{2l}$$

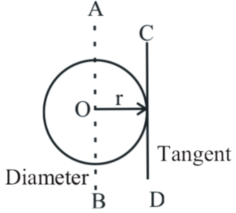
444. The moment of inertia of a uniform ring of mass M and radius r about a tangent lying in its own plane is

(a) $2Mr^2$ (b) $\frac{3}{2}Mr^2$

(c) Mr^2 (d) $\frac{1}{2}Mr^2$

Kerala PET-2010
CG PET- 2004
RPET-2001
MP PET-1997

Ans. (b) : Let, the tangent be represent by CD and diameter be represent by AB.



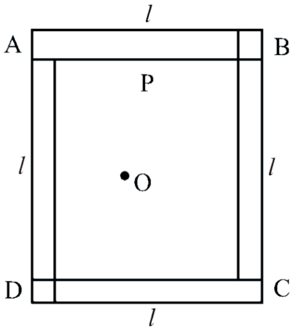
Moment of inertia about diameter $(I_a) = \frac{1}{2}Mr^2$

Moment of inertia about tangent

$$I_{CD} = \frac{Mr^2}{2} + Mr^2$$

$$= \frac{3}{2}Mr^2$$

445. Four thin rods of same mass M and same length l, form a square as shown in figure. Moment of inertia of this system about an axis through centre O and perpendicular to its plane is

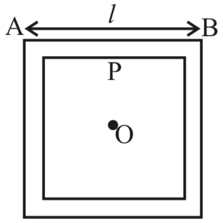


(a) $\frac{4}{3}Ml^2$ (b) $\frac{Ml^2}{3}$

(c) $\frac{Ml^2}{6}$ (d) $\frac{2}{3}Ml^2$

Manipal UGET-2014
AIPMT-2009
MP PMT-2002

Ans. (a) : Given mass of thin rod = M, length = l



Moment of inertia of rod AB about point P and perpendicular to the plane $= \frac{Ml^2}{12}$

Moment of inertia of rod AB about point O

$$= \frac{Ml^2}{12} + M\left(\frac{l}{2}\right)^2 = \frac{Ml^2}{3}$$

But the system consists of four rods of similar type so by the symmetry,

$$I_{system} = 4\left(\frac{Ml^2}{3}\right) = \frac{4Ml^2}{3}$$

446. The moment of inertia of a rod about an axis through its centre and perpendicular to it is $\frac{1}{12}ML^2$ (where, M is the mass and L the length of the rod). The rod is bent in the middle so that the two halves make an angle of 60°. The moment of inertia of the bent rod about the same axis would be

(a) $\frac{ML^2}{48}$ (b) $\frac{ML^2}{12}$

(c) $\frac{ML^2}{24}$ (d) $\frac{ML^2}{8\sqrt{3}}$

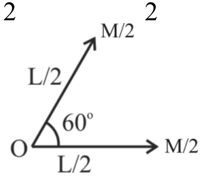
UPSEE - 2015
AIPMT-2008
AIIMS-2006

Ans. (b) : Given that,

Length of the rod = L

Mass of the rod = M

Since the rod is bent at the middle, so each part of it will have same length $\frac{L}{2}$ and mass $\frac{M}{2}$



Moment of inertia of each part through its one end

$$I = \frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2$$

@apna_pdf

Hence, Net moment of inertia through its middle point O is

$$I=\frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2+\frac{1}{3}\frac{M}{2}\left(\frac{L}{2}\right)^2$$

$$I=\frac{1}{3}\times\frac{ML^2}{8}+\frac{1}{3}\times\frac{ML^2}{8}$$

$$I=\frac{1}{3}\left[\frac{ML^2}{8}+\frac{ML^2}{8}\right]=\frac{ML^2}{12}$$

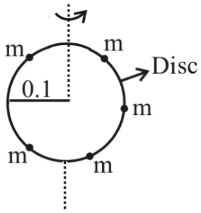
447. Five particles of mass 2 kg are attached to the rim of a circular disc of radius 0.1 m and negligible mass. Moment of inertia of the system about the axis passing through the centre of the disc and perpendicular to its plane is

(a) 1 kg m^2 (b) 0.1 kg m^2

(c) 2 kg m^2 (d) 0.2 kg m^2

RPMT-2006
UP CPMT-2004
BHU-2003

Ans. (b) : Given,
Mass of particle m = 2 kg
Radius of circular disc = 0.1 m
According to question,



As we know that,
Moment of inertia of a circular disc about an axis through its center of mass and perpendicular to the disc

$I_{c.m} = MR^2$

$I_{net} = 5\times I_{each}$

$= 5\ mr^2$

$= 5\ mr^2 = 5 \times 2 \times(0.1)^2$

$= 10 \times 1/100 = 0.1\ kg.m^2$

$I_{net} = 0.1\ Kg.\ m^2$

448. The ratio of the radii of gyration of a circular disc to that of a circular ring, each of same mass and radius, around their respective axis is

(a) $\sqrt{3}:\sqrt{2}$ (b) $1:\sqrt{2}$

(c) $\sqrt{3}:1$ (d) $\sqrt{5}:\sqrt{3}$

JCECE-2014
NEET (Karnataka)-2013
AIPMT-2008

Ans. (b) : Radius of gyration,
∵ Moment of inertia, $I = MK^2$

$$K^2=\frac{I}{M}$$

$$\text{Radius of gyration, } K=\sqrt{\frac{I}{M}}$$

Moment of inertia of disc, $I=\frac{1}{2}MR^2$

$$K_{disc}=\sqrt{\frac{I}{M}}=\sqrt{\frac{\frac{1}{2}MR^2}{M}}$$

$$K_{disc}=\sqrt{\frac{R^2}{2}} \qquad \text{....(i)}$$

Moment of inertia of ring, $I = MR^2$

$$K_{ring}=\sqrt{\frac{MR^2}{M}}$$

$$K_{ring}=\sqrt{R^2} \qquad \text{....(ii)}$$

Form eq.(i) ÷ (ii),

$$\because \frac{K_{disc}}{K_{ring}}=\frac{\sqrt{\frac{1}{2}R^2}}{\sqrt{R^2}}=\frac{1}{\sqrt{2}}$$

$$K_{disc}:K_{ring}=1:\sqrt{2}$$

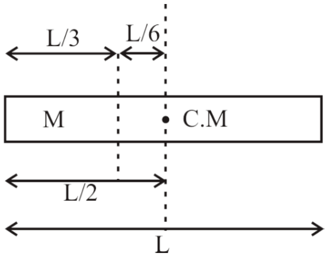
449. The moment of inertia of a uniform thin rod of length L and mass M about an axis passing through a point at a distance $\frac{L}{3}$ from one of its ends and perpendicular to the rod is

(a) $\frac{7ML^2}{48}$ (b) $\frac{ML^2}{9}$

(c) $\frac{ML^2}{12}$ (d) $\frac{ML^2}{3}$

AMU-2010
CG PET- 2005
MP PMT-1995

Ans. (b) :



According to parallel axis theorem–

$$I=I_{cm}+M\left(\frac{L}{6}\right)^2$$

$$I=\frac{ML^2}{12}+M\left(\frac{L}{6}\right)^2$$

$$=\frac{ML^2}{12}+\frac{ML^2}{36}$$

$$=\frac{4ML^2}{36}\quad=\frac{ML^2}{9}$$

@apna_pdf

450. From a disc of mass 'M' and radius 'R', a circular hole of a diameter 'R' is cut whose rim passes through the centre. The moment of inertia of the remaining part of the disc about perpendicular axis passing through the centre is

(a) $\frac{9MR^2}{32}$ (b) $\frac{13MR^2}{32}$

(c) $\frac{11MR^2}{32}$ (d) $\frac{7MR^2}{32}$

MHT CET-2020, 2019
NEET-2016

Ans. (b) : Given that, mass of disc = M, radius of disc = R

Moment of inertia $\left(I_{\text{big disc}}\right) = \frac{1}{2}MR^2$ ....(i)

Let, moment of inertia of small disc is I_1 which is cut from big disc.

So, $I_{\text{remaining}} = I_{\text{big disc}} - I_1$ ....(ii)

From parallel axis theorem, moment of inertia of the small disc $(I_1) = I_c + m_1 R_1^2$

$$I_1 = \frac{1}{2}.\frac{M}{4}.\left(\frac{R}{2}\right)^2 + \frac{M}{4}\times\left(\frac{R}{2}\right)^2 \quad \left[\begin{array}{l}\because m_1 = M/4 \\ R_1 = R/2\end{array} \& I_c = \frac{1}{2}m_1R_1^2\right]$$

$$= \frac{MR^2}{32} + \frac{MR^2}{16}$$

$$I_1 = \frac{3MR^2}{32}$$

Putting the value of these in equation (ii), we get–

$$\therefore \quad I_{\text{remaining}} = I_{\text{big disc}} - I_1$$

$$I_{\text{remaining}} = \frac{1}{2}MR^2 - \frac{3MR^2}{32}$$

$$I_{\text{remaining}} = \frac{13MR^2}{32}$$

451. A solid sphere of radius R has its outer half removed, so that its radius becomes (R/2). Then its moment of inertia about the diameter is

(a) becomes $\frac{1}{2}$ of its initial volume

(b) is unchanged.

(c) becomes $\frac{1}{16}$ of initial volume.

(d) becomes $\frac{1}{32}$ of initial volume.

AP EAMCET-04.07.2022, Shift-II

Ans. (d) : Initial Radius $R_1 = R$

Final Radius $R_2 = \frac{R}{2}$

Lets density of solid sphere = ρ

Initial mass $M_1 = \frac{4}{3}\pi R_1^3.\rho$

$$M_1 = \frac{4}{3}\pi\rho R^3$$

Final mass $M_2 = \frac{4}{3}\pi R_2^3.\rho$

$$M_2 = \frac{4}{3}\pi\rho\left(\frac{R}{2}\right)^3$$

$$M_2 = \frac{1}{8}\times\frac{4}{3}\pi\rho R^3$$

$$M_2 = \frac{1}{8}M_1$$

Initial moment of inertia of solid sphere.

$$I_1 = \frac{2}{5}M_1R_1^2$$

$$I_1 = \frac{2}{5}M_1R^2$$

Final moment of Inertia of solid sphere.

$$I_2 = \frac{2}{5}M_2R_2^2$$

$$I_2 = \frac{2}{5}\times\frac{1}{8}M_1\times\left(\frac{R}{2}\right)^2$$

$$I_2 = \frac{2}{5}\times\frac{M_1R^2}{8\times4}$$

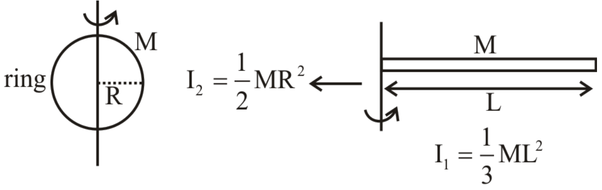
$$I_2 = \frac{1}{32}\times\frac{2}{5}M_1R^2$$

$$I_2 = \frac{I_1}{32}$$

452. The moment of inertia of a uniform thin rod about a perpendicular axis passing through one end is I_1. The same rod is bent into a ring and its moment of inertia about a diameter is I_2. If $\frac{I_1}{I_2}$ is $\frac{x\pi^2}{3}$, then the value of x will be ______.

JEE Main-29.06.2022, Shift-II

Ans. (8) : According to question,



Where,

$$L = 2\pi R,$$

$$R = \frac{L}{2\pi}$$

The moment of inertia of a uniform thin rod about the perpendicular through one end is,

$$I_1 = \frac{1}{3}ML^2 \quad ....(i)$$

Moment of inertia of ring about diameter

$$I_2 = \frac{1}{2}MR^2 \quad ....(ii)$$

From equation (i) and (ii) we get,

$$\frac{I_1}{I_2} = \frac{\frac{1}{3}ML^2}{\frac{M}{2}\left(\frac{L}{2\pi}\right)^2} = \frac{8\pi^2}{3} = \frac{x\pi^2}{3}$$

Then, x = 8

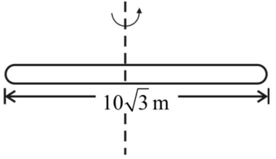
@apna_pdf

453. The radius of gyration of a cylindrical rod about an axis of rotation perpendicular to its length and passing through the center will be——m.

Given, the length of the rod is $10\sqrt{3}$ m.

JEE Main-26.07.2022, Shift-II

Ans. (5) : Given, length of the rod (L) = $10\sqrt{3}$



We know that,

$$I = \frac{ML^2}{12}$$

$$Mk^2 = \frac{ML^2}{12} \qquad (\because I = Mk^2)$$

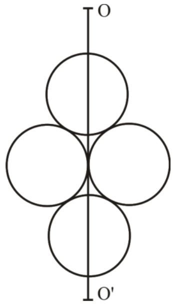
Where k is radius of gyration

$$k = \frac{L}{2\sqrt{3}}$$

$$k = \frac{10\sqrt{3}}{2\sqrt{3}}$$

$$k = 5$$

454. Four identical discs each of mass 'M' and diameter 'a' are arranged in a small plane as shown in figure. If the moment of inertia of the system about OO' is $\frac{x}{4}Ma^2$. Then, value of x will be ________.

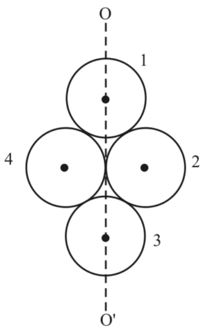


JEE Main-28.07.2022, Shift-I

Ans. (3) : Given, mass of each identical disc = M
and diameter = a, radius = a/2
Moment of inertia of the system about OO',

$$(I_{OO'}) = \frac{x}{4}Ma^2 \qquad \text{....(i)}$$

$$I_1 = I_3 = \frac{MR^2}{4}$$



From parallel axis theorem

$$I_2 = \frac{MR^2}{4} + MR^2$$

$$I_2 = \frac{5}{4}MR^2 = I_4$$

The moment of inertia of the system about O O' is,

$$I_{OO'} = I_1 + I_2 + I_3 + I_4$$

$$= \frac{MR^2}{4} + \frac{5}{4}MR^2 + \frac{MR^2}{4} + \frac{5}{4}MR^2$$

$$I_{OO'} = 3\ MR^2$$

Putting the value of $R = \frac{a}{2}$

$$I_{OO'} = \frac{3Ma^2}{4} \qquad \text{....(ii)}$$

From equation (i) and (ii), we get

$$x = 3$$

455. Match List-I With List-II

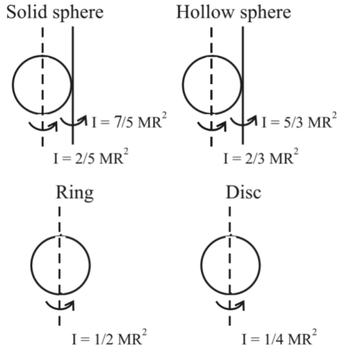
	List-I		List-II
A.	**Moment of inertia of solid sphere of radius R about any tangent**	**I.**	$\frac{5}{3}MR^2$
B.	**Moment of inertia of hollow sphere of radius (R) about any tangent.**	**II.**	$\frac{7}{5}MR^2$
C.	**Moment of inertia of circular ring of radius (R) about its diameter.**	**III.**	$\frac{1}{4}MR^2$
D.	**Moment of inertia of circular disc of radius (R) about any diameter.**	**IV.**	$\frac{1}{2}MR^2$

Choose the correct answer from the options given below.

(a) A-II, B-I, C-IV, D-III
(b) A-I, B-II, C-IV, D-III
(c) A-II, B-I, C-III, D-IV
(d) A-I, B-II, C-III, D-IV

JEE Main-28.06.2022, Shift-I

Ans. (a) :



456. Moment of Inertia (M.I.) of four bodies having same mass 'M' and radius '2R' are as follows :

I_1 = M.I. of solid sphere about its diameter

I_2 = M.I. of solid cylinder about its axis

I_3 = M.I. of solid circular disc about its diameter

@apna_pdf

I_4 = M.I. of thin circular ring about its diameter
If $2(I_2 + I_3) + I_4 = x.\ I_1$ then the value of x will be __________.

JEE Main-25.06.2022, Shift-II

Ans. (5) : According to question

I_1 = M.I. of solid sphere about its diameter

$$=\frac{2}{5}M(2R)^2$$

I_2 = M.I. of solid cylinder about its axis = $\frac{1}{2}M(2R)^2$

I_3 = M.I. of solid circular disc about its diameter

$$=\frac{1}{4}M(2R)^2$$

I_4 = M.I. of circular ring about its diameter = $\frac{1}{2}M(2R)^2$

Given,

$$2[I_2 + I_3] + I_4 = xI_1$$

$$2\left[\frac{1}{2}M(2R)^2+\frac{1}{4}M(2R)^2\right]+\frac{1}{2}M(2R)^2 = x\frac{2}{5}M(2R)^2$$

$$2\left[\frac{3}{4}M(2R)^2\right]+\frac{1}{2}M(2R)^2 = x\frac{2}{5}M(2R)^2$$

$$2M(2R)^2 = x.\frac{2}{5}M(2R)^2$$

$$x.\frac{2}{5}=2$$

$$x = 5$$

457. An energy of 484 J is spent in increasing the speed of a flywheel from 60 rpm to 360 rpm. The moment of inertia of the flywheel is:

(a) 0.7 kg-m^2 (b) 3.22 kg-m^2
(c) 30.8 kg-m^2 (d) 0.07 kg-m^2

NEET-17.07.2022

Ans. (a) : Given that,

Energy (E) = 484 J

Speed of the flywheel (n) = 60 rpm to 360 rpm

We know that-

$$\Delta E=\frac{1}{2}I(\omega_f^2-\omega_i^2) \qquad (\because\ \omega = 2\pi n)$$

$$484=\frac{1}{2}I\left[\left(2\pi\times\frac{360}{60}\right)^2-\left(2\pi\times\frac{60}{60}\right)^2\right]$$

$$484=\frac{1}{2}I\left[144\pi^2-4\pi^2\right]$$

$$484=\frac{1}{2}I\times140\pi^2$$

$$I=\frac{484\times2}{140\pi^2}=\frac{6.91}{\pi^2}=0.7\text{kg.m}^2$$

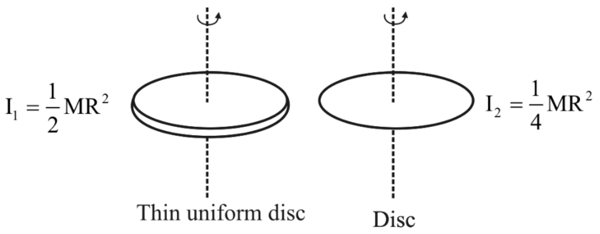
$$I = 0.7\ \text{kg.m}^2$$

458. The ratio of the radius of gyration of a thin uniform disc about an axis passing through its centre and normal to its plane to the radius of gyration of the disc about its diameter is

(a) 4:1 (b) $1:\sqrt{2}$
(c) 2:1 (d) $\sqrt{2}:1$

NEET-17.07.2022

Ans. (d) : According to question-



As we know that,

Radius of gyration $\left[k=\sqrt{\frac{I}{M}}\right]$

The radius of gyration of the uniform disc

$$k_1=\sqrt{\frac{\frac{MR^2}{2}}{M}}=\sqrt{\frac{R^2}{2}} \qquad \text{....(i)}$$

The radius of gyration of the disc

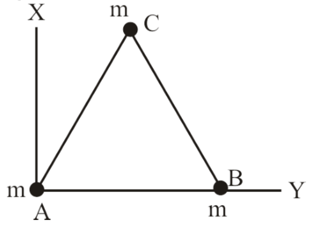
$$k_2=\sqrt{\frac{\frac{MR^2}{4}}{M}}=\sqrt{\frac{R^2}{4}} \qquad \text{......(ii)}$$

From equation (i) and (ii), we get –

$$\frac{k_1}{k_2}=\frac{\sqrt{\frac{R^2}{2}}}{\sqrt{\frac{R^2}{4}}}=\frac{2}{\sqrt{2}}=\sqrt{2}$$

$$k_1 : k_2 = \sqrt{2}:1$$

459. Three particles, each of mass 'm' grams situated at the vertices of an equilateral ΔABC of side 'a' cm (as shown in the figure). The moment of inertia of the system about a line AX perpendicular to AB and in the plane of ABC in g-cm^2 units will be

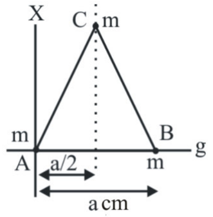


(a) 2 ma^2 (b) $\frac{3}{2}$ ma^2
(c) $\frac{3}{4}$ma^2 (d) $\frac{5}{4}$ma^2

WB JEE 2022
AI PMT - 2004

@apna_pdf

Ans. (d) : According to question–
AX-line is perpendicular to AB line and in plane of ΔABC



$$I_{net} = I_A+I_B+I_C = 0 + ma^2 + m(a/2)^2$$
$$I = 5/4\ ma^2$$

460. Radius of gyration of a solid cylinder of radius R and length L about its long axis of symmetry is

(a) R (b) $\frac{R}{\sqrt{2}}$
(c) $\sqrt{2}R$ (d) $\frac{R}{2}$
(e) 2R

Kerala CEE 2021

Ans. (b) : For solid cylinder along its geometrical axis

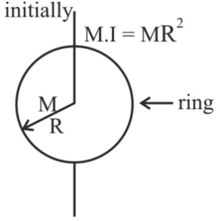
$$\text{M.I.} = \frac{1}{2}MR^2$$
$$MK^2 = \frac{1}{2}MR^2$$
$$K^2 = \frac{R^2}{2}$$
$$\boxed{K = \frac{R}{\sqrt{2}}}$$

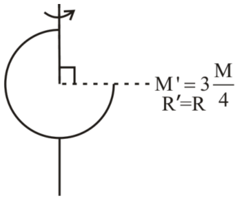
461. From a circular ring of mass M and radius R, an arc corresponding to a 90° sector is removed. The moment of inertia of the remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is K times MR^2. Then, the value of K is

(a) $\frac{3}{4}$ (b) $\frac{7}{8}$
(c) $\frac{1}{4}$ (d) $\frac{1}{8}$

NEET- 2021

Ans. (a) : According to question





Moment of Inertia of initial ring × K= Moment of inertia of remaining part

$$K \times MR^2 = \frac{3}{4}MR^2$$
$$K = \frac{3}{4}$$

462. A wheel having moment of inertia 40 kg.m^2 about its axis, rotates at 50 rpm. The angular retardation required to stop this wheel in 90 seconds is _______ rad.s^{-2}

(a) $\frac{\pi}{45}$ (b) $\frac{\pi}{30}$
(c) $\frac{\pi}{54}$ (d) $\frac{\pi}{24}$

AP EAMCET-23.08.2021, Shift-I

Ans. (c) : Given that,
A wheel have moment of Inertia = 40 kg-m^2
It rotates at 50 rpm about the axis.
To find:- The angular retardation required to stop this wheel in 90 seconds
t = 90 seconds
Initial Angular velocity (ω_0) = 50 rpm
Now converting in rad/sec

$$\omega_0 = 50 \times \frac{2\pi}{60}\ \text{rad/sec}$$
$$\omega_0 = \frac{5\pi}{3}\ \text{rad/sec}$$

We know that,
$\omega = \omega_0 + \alpha t$
$0 = \omega_0 + \alpha t$
$\alpha t = -\omega_0$

$$\alpha = -\frac{\omega_0}{t}$$
$$\alpha = -\frac{\frac{5\pi}{3}}{90}$$
$$\alpha = -\frac{5\pi}{3\times 90}$$
$$\alpha = -\frac{\pi}{3\times 18}$$
$$\alpha = -\frac{\pi}{54}\text{rad.s}^{-2}$$

Retardation, $\alpha = \frac{\pi}{54}\text{rad.s}^{-2}$

463. If an energy of 684 J is needed to increase the speed of a fly wheel from 180 rpm to 360 rpm, then find its moment of inertia.

(a) 0.7 kg. m^2 (b) 1.28 kg. m^2
(c) 2.75 kg. m^2 (d) 7.28 kg. m^2

AP EAMCET-20.08.2021, Shift-I

Ans. (b) : Given,
Energy (E) = 684 J

Final angular velocity (ω_f) = $360 \times \frac{2\pi}{60} = 12\pi$ rps

Initial angular velocity (ω_i) = $180 \times \frac{2\pi}{60} = 6\pi$ rps

We know,

$$E = \frac{1}{2}\ I_{wheel}\left(\omega_f^2 - \omega_i^2\right)$$

@apna_pdf

$$684 \times 2 = I_{wheel} \times [144\pi^2 - 36\pi^2]$$

$$I_{wheel} = \frac{684 \times 2}{108 \times \pi^2} \text{ kg.m}^2$$

$$I_{wheel} = 1.28 \text{ kg.m}^2$$

464. The distance between the carbon atom and the oxygen atom in a carbon monoxide molecule is 1.1 $\overset{o}{A}$. Given, mass of carbon atom is 12 a.m.u. and mass of oxygen atom is 16 a.m.u. Calculate the position of the centre of mass of the carbon monoxide molecule.

(a) 6.3 Å from the Carbon atom

(b) 1.0 Å from the Oxygen atom

(c) 0.63 Å from the Carbon atom

(d) 0.12 Å from the Oxygen atom

AP EAMCET-24.08.2021, Shift-II

Ans. (c) : Given, $m_1 = 12$ amu, $m_2 = 16$ amu

$x_1 = 0$ Å , $x_2 = 1.1$ Å

Centre of mass of the carbon monoxide molecule from carbon atom –

$$X_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$X_{cm} = \frac{12 \times 0 + 16 \times 1.1}{12 + 16}$$

$$X_{cm} = 0.63 \text{ Å}$$

465. Which of the following type of wheels of same mass and radius will have largest moment of inertia?

(a) Ring (b) Angular disc

(c) Solid disc (d) Cylindrical disc

AP EAMCET-19.08.2021, Shift-I

Ans. (a) : A ring has an greater moment of inertia than a circular disc of the same mass and radius about an axis that passes through its center of mass perpendicular to its plane. A ring has a large moment of inertia because its entire mass is concentrated at the rim from maximum distance about its axis.

466. The moment of inertia of a thin rod of mass 'M' and length 'L' about an axis passing through a point at a distance $\frac{L}{4}$ from its center and perpendicular to its length is ______

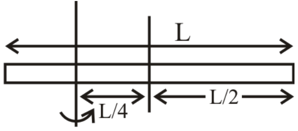
(a) $\frac{ML^3}{48}$ (b) $\frac{ML^2}{48}$

(c) $\frac{ML^2}{12}$ (d) $\frac{7ML^2}{48}$

AP EAMCET-25.08.2021, Shift-I

Ans. (d) : Given, mass of thin rod = M

Length of thin rod = L



Applying parallel axis theorem,

Moment of inertia (I) = $I_a + Mx^2$

$$I = \frac{ML^2}{12} + M\left(\frac{L}{4}\right)^2$$

$$I = \frac{ML^2}{12} + \frac{ML^2}{16}$$

$$I = \frac{7}{48} ML^2$$

467. The moment of inertia of a hollow square cube of side length a and mass M about an axis passing through the center of the cube is a

(a) $\frac{1}{18}Ma^2$ (b) $\frac{1}{6}Ma^2$

(c) $\frac{5}{6}Ma^2$ (d) $\frac{5}{18}Ma^2$

Assam CEE-2021

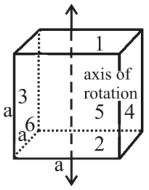
Ans. (d) : Given that,

Hollow square cube of side length = a

Each square plate of mass = m

Total mass of square cube M = 6 m

M.O.I of square plate about axis through C.O.M and perpendicular to its plane = $\frac{ma^2}{6}$



Axis of rotation passes through center of mass of two square plates (1) and (2) facing opposite to each other

$$I_2 = I_1 = \frac{ma^2}{6} \quad ....(i)$$

M.O.I of a square plate about axis passing through C.O.M and parallel to its plane is.

$$I = \frac{ma^2}{12}$$

and the remaining 4 plates have a distance of from the cube axis.

By parallel axis theorem, M.O.I of plate (3), (4), (5) and (6) about cube axis is

$$I_3 = I_4 = I_5 = I_6 = \frac{ma^2}{12} + m\left(\frac{a}{2}\right)^2 = \frac{ma^2}{3} \quad ....(ii)$$

Therefore, total M.O.I about cube axis is,

$$I = I_1 + I_2 + I_3 + I_4 + I_5 + I_6$$

$$I = 2I_1 + 4I_3 \quad \text{[from (i) and (ii)]}$$

$$= 2 \times \frac{ma^2}{6} + 4 \times \frac{ma^2}{3} = \frac{5ma^2}{3}$$

$$I = \frac{5ma^2}{3} \quad (\because M = 6m)$$

$$I = \frac{5 \times Ma^2}{6 \times 3} \quad \left(\because m = \frac{M}{6}\right)$$

$$I = \frac{5Ma^2}{18}$$

@apna_pdf

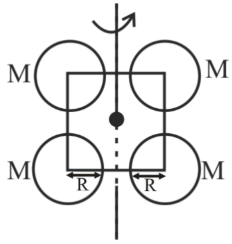
468. Four identical rings of radius R and mass M are placed at the corner of a square in x-y plane such that each ring touches the two rings tangentially. The moment of inertia of this system about z-axis passing through the centre of the square is

(a) 8 MR^2 (b) 7 MR^2

(c) 6 MR^2 (d) 4 MR^2

UPSEE 2020

Ans. (c) : According to question



M.I. of system = 4 × M.I. of each ring apply parallel axis theorem

$(MI)_{system} = 4\times[MR^2 + Mx^2]$

$$= 4\left[MR^2 + M\left(\frac{R}{\sqrt{2}}\right)^2\right] \qquad \left[\text{Where, } x = \frac{R}{\sqrt{2}}\right]$$

$$= 4\left[MR^2 + \frac{MR^2}{2}\right]$$

$(M.I.)_{system} = 6\ MR^2$

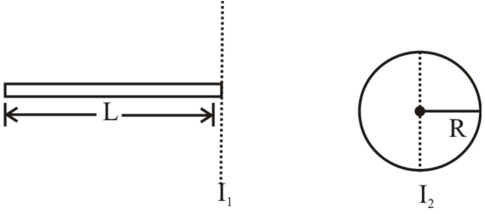
469. The moment of inertia of a thin uniform rod about a perpendicular axis passing through one of its ends is 'I'. Now, the rod is bent in a ring and its moment of inertia about diameter is 'I_1', Then I/I_1 is

(a) $\frac{8\pi^2}{3}$ (b) $\frac{\pi^2}{3}$

(c) $\frac{11\pi^2}{3}$ (d) $\frac{4\pi^2}{3}$

MHT-CET 2020
MHT-CET-2014

Ans. (a) :



Circumference of ring = Length of rod

$$2\pi R = L$$

or $$R = \frac{L}{2\pi} \qquad \dots (i)$$

Moment of inertia of one of its ends of rod

$$I = \frac{ML^2}{3} \qquad \dots (ii)$$

Moment of inertia of ring $(I_1) = \frac{MR^2}{2}$

Putting the value of R from equation (i), we get

$$I_1 = \frac{ML^2}{8\pi^2} \qquad \dots (iii)$$

Taking ratio of equation (ii) and (iii), we get

$$\frac{I}{I_1} = \frac{ML^2}{3}\times\frac{8\pi^2}{ML^2}$$

$$\frac{I}{I_1} = \frac{8}{3}\pi^2$$

470. Let M and L be the mass and length of thin uniform rod respectively. In 1st case, axis of rotation is passing through centre and perpendicular to its length. In 2nd case, axis of rotation is passing through one end and perpendicular to its length. The ratio of radius of gyration in first case to second case is

(a) 1 : 2 (b) 2 : 1

(c) 3 : 1 (d) 1 : 3

MHT-CET- 2020
MHT-CET-2016

Ans. (a) : Given, mass of thin rod = M

Length of thin rod = L

From 1st case –

$$I_1 = \frac{ML^2}{12} \qquad \dots (i)$$

And $$I_1 = MK_1^2 \qquad \dots (ii)$$

Equating equation (i) and (ii), we get

$$K_1 = \frac{L}{\sqrt{12}}$$

From IInd case –

$$I_2 = \frac{ML^2}{3} \qquad \dots (iii)$$

And $$I_2 = MK_2^2 \qquad \dots (iv)$$

Equating equation (iii) and (iv), we get

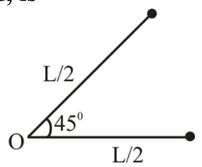
$$K_2 = \frac{L}{\sqrt{3}}$$

Taking ratios of K_1 and K_2, we get

$$\frac{K_1}{K_2} = \frac{L}{\sqrt{12}}\times\frac{\sqrt{3}}{L}$$

$$\therefore \quad \frac{K_1}{K_2} = \frac{1}{2}$$

471. A thin uniform rod of length 'L' and mass 'M' is bent at the middle point 'O' at an angle of 45^0 as shown in the figure. The moment of inertia of the system about an axis passing through 'O' and perpendicular to the plane of the bent rod, is



(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{24}$

@apna_pdf

(c) $\frac{ML^2}{3}$ (d) $\frac{ML^2}{12}$

MHT-CET 2020

Ans. (d) : Given, length of rod = L

mass of rod = M

When rod is bent at the middle so each part of it will have the same length $\left(\frac{L}{2}\right)$ and mass $\left(\frac{M}{2}\right)$ then-

Moment of inertia of each part-

$$I_1 = \frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2 = \frac{ML^2}{24} \qquad \text{....(i)}$$

$\therefore$ Total moment of inertia –

$$I = 2I_1$$

Putting the value of I_1 from equation (i), we get-

$$I = 2 \times \frac{ML^2}{24}$$

$$I = \frac{ML^2}{12}$$

472. A solid sphere of mass 'M' and radius 'R' has moment of inertia 'I' about its diameter. It recast into a disc of thickness 't' whose moment of inertia about an axis passing through its edge and perpendicular to its plane, remains 'I'. Radius of the disc will be

(a) $\frac{R}{\sqrt{19}}$ (b) $\frac{2R}{\sqrt{15}}$

(c) $\frac{2R}{\sqrt{19}}$ (d) $\frac{R}{\sqrt{15}}$

MHT-CET 2020

Ans. (b) : Given, mass of solid sphere = M

Radius of sphere = R

Radius of disk = r

Moment of inertia of solid sphere (I) = $\frac{2}{5}MR^2$

Moment of inertia of disc = $\frac{1}{2}Mr^2$

From parallel axis theorem -

$$I = I_{CM} + Mr^2$$

$$\frac{2}{5}MR^2 = \frac{1}{2}Mr^2 + Mr^2 = \frac{3}{2}Mr^2$$

$$\frac{2}{5}MR^2 = \frac{3}{2}Mr^2$$

$$r = \frac{2}{\sqrt{15}}R$$

473. A ring and a disc have same mass and same radius. The ratio of moment of inertia of a ring about a tangent in its plane to that of the disc about its diameter is

(a) 6 : 1 (b) 4 : 1

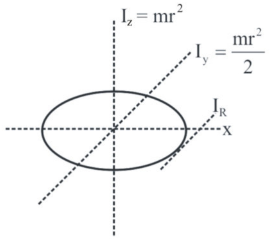
(c) 2 : 1 (d) 8 : 1

MHT-CET 2020

Ans. (a) : Let, mass = m, radius = r

For ring –

By Perpendicular axis theorem



$$I_z = I_x + I_y \qquad [\because I_x = I_y]$$

$$I_z = 2I_y$$

$$I_y = \frac{I_z}{2} = \frac{mr^2}{2}$$

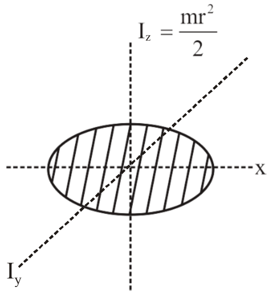
By using parallel axis theorem –

$$I_R = I_{com} + mx^2$$

$$I_R = \frac{mr^2}{2} + mr^2 \qquad [\because x = r]$$

$$I_R = \frac{3}{2}mr^2$$

Disc –



$$I_y = \frac{I_z}{2}$$

$$I_y = \frac{mr^2}{4} = I_D$$

$$\frac{I_R}{I_D} = \frac{3}{2}\frac{mr^2}{mr^2} \times 4$$

$$I_R : I_D = 6 : 1$$

474. From a uniform circular thin disc of mass 9M and radius R, a small disc of radius $\frac{R}{3}$ is removed. The centre of the small disc is at a distance $\frac{2R}{3}$ from the centre of original disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through the centre of the disc of radius R is

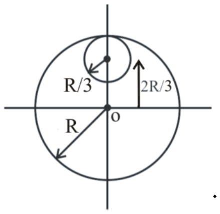
(a) $\frac{MR^2}{2}$ (b) $4\ MR^2$

(c) MR^2 (d) $3\ MR^2$

MHT-CET 2020

@apna_pdf

Ans. (b) : Using negative mass concept,



The moment of inertia of residue disc is-

$$I=\frac{9MR^2}{2}-\left[\frac{M\left(\frac{R}{3}\right)^2}{2}+M\left(\frac{2R}{3}\right)^2\right]$$

$$I=\frac{9MR^2}{2}-\left[\frac{MR^2}{18}+\frac{4MR^2}{9}\right]$$

$$I=\frac{9MR^2}{2}-\frac{MR^2}{18}-\frac{4MR^2}{9}$$

$$I=MR^2\left[\frac{9}{2}-\frac{1}{18}-\frac{4}{9}\right]$$

$$I=MR^2\left[\frac{81-1-8}{18}\right]$$

$$I=MR^2\left[\frac{81-9}{18}\right]$$

$$I=MR^2\times\frac{72}{18}$$

$$I=4\ MR^2$$

475. A disc of mass 10kg and radius 0.1m is rotating at 120r.p.m. A retarding torque brings it to rest in 10s. If the same torque is due to force applied tangentially on the rim of the disc then magnitude of force is

(a) 0.1 πN
(b) 0.2 πN
(c) 0.4 πN
(d) 0.8 πN

MHT-CET 2020

Ans. (b) : Given,

mass (m) = 10 kg, radius (r) = 0.1 m, time (t) = 10s

$$f=120\text{ rpm}$$

$$f=\frac{120}{60}$$

$$f=2\text{ rps}$$

We know that,

$$\omega=2\pi f$$

$$\omega=2\pi\times2$$

$$\omega=4\pi\text{ rad/s}$$

Angular acceleration

$$\alpha=\frac{\omega_1-\omega}{t}$$

$$\alpha=\frac{0-4\pi}{10}$$

$$\alpha=\frac{-2\pi}{5}$$

Moment of inertia

$$I=\frac{mr^2}{2}=\frac{10\times(0.1)^2}{2}=0.05\text{ kg-m}^2$$

Retarding torque –

$$\tau=I\alpha$$

$$\tau=0.05\times\frac{2\pi}{5}$$

$$\tau=0.02\pi\text{ N-m}$$

$$\because\quad\tau=Fr$$

$$F=\frac{\tau}{r}$$

$$F=\frac{0.02\pi}{0.1}$$

$$F=0.2\pi\text{ N}$$

476. Moment of inertia of a solid sphere about its diameter is 'I'. It is then casted into 27 small sphere of same diameter. The moment of inertia of each new sphere is

(a) $\frac{I}{31}$
(b) $\frac{I}{122}$
(c) $\frac{I}{243}$
(d) $\frac{I}{62}$

MHT-CET 2020

Ans. (c) : Let M and R be the mass and radius of sphere initially and m and r be the mass and radius of smaller spheres after casting.

We know that,

Moment of inertia of a solid sphere (I) = $\frac{2}{5}MR^2$

Since the volume remain constant,

$$27\times\frac{4}{3}\pi r^3=\frac{4}{3}\pi R^3$$

$$27r^3=R^3$$

$$3r=R$$

$$r=\frac{R}{3}$$

and, $m=\frac{M}{27}$ $(\because M=27m,\text{ given})$

Now, $I=\frac{2}{5}MR^2$ and $I'=\frac{2}{5}mr^2$

$$I'=\frac{2}{5}\left(\frac{M}{27}\right)\left(\frac{R}{3}\right)^2$$

$$I'=\left(\frac{2}{5}MR^2\right)\frac{1}{243}$$

$$I'=\frac{I}{243}$$

477. A thin wire of length 'L' and uniform linear mass density 'm' is bent into a circular loop. The moment of inertia of this loop about the tangential axis and in the plane of the coil is

(a) $\frac{3mL^3}{4\pi^2}$
(b) $\frac{3mL^3}{8\pi^2}$

@apna_pdf

(c) $\frac{3mL^3}{16\pi^2}$ (d) $\frac{3mL^3}{2\pi^2}$

MHT-CET 2020

Ans. (b) : Mass of thin wire M = mL
Now,

Circumference, $2\pi R = L$

$$R = \frac{L}{2\pi}$$

The moment of inertia of this loop about the tangential axis and in the plane of the coil is

$$I = \frac{MR^2}{2} + MR^2$$

$$I = \frac{3}{2}MR^2$$

$$I = \frac{3}{2}\times mL\times\left(\frac{L}{2\pi}\right)^2$$

$$I = \frac{3mL^3}{8\pi^2}$$

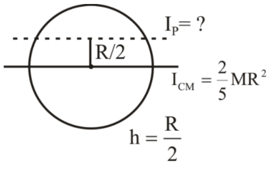
478. A solid sphere has mass 'M' and radius 'R'. Its moment of inertia about a parallel axis passing through a point at a distance $\frac{R}{2}$ from its centre is

(a) $\frac{13}{20}MR^2$ (b) $\frac{8}{11}MR^2$

(c) $\frac{11}{15}MR^2$ (d) $\frac{6}{10}MR^2$

MHT-CET 2020

Ans. (a) :



According to parallel axis theorem the moment of inertia

$$I_P = I_{CM} + Mh^2$$

$$I_P = \frac{2}{5}MR^2 + M\left(\frac{R}{2}\right)^2$$

$$I_P = \frac{2}{5}MR^2 + \frac{MR^2}{4}$$

$$I_P = \frac{8MR^2 + 5MR^2}{20}$$

$$I_P = \frac{13}{20}MR^2$$

479. Two discs A and B of equal mass and thickness have densities 6800 kg/m^3 and 8500 kg/m^3 respectively. The ratio of their moments of inertia (A to B) is

(a) $\frac{1}{6.8\times 8.5}$ (b) $\frac{4}{5}$

(c) $\frac{5}{4}$ (d) $\frac{5}{9}$

MHT-CET 2020

Ans. (c) : Given,
Density $\rho_1 = 6800$ kg/m^3 and density $\rho_2 = 8500$ kg/m^3
Moment of inertia for disc –

$I = \frac{1}{2}mr^2$.............(i)

Volume of disc (V) = $\pi r^2 t$

Mass of the disc (m) = ρV $\left\{\because \rho = \frac{m}{V}\right\}$

$$m = \rho\times\pi r^2 t$$

$$r^2 = \frac{m}{\rho\pi t}$$

Hence,

$$I = \frac{1}{2}m.\left(\frac{m}{\rho\pi t}\right)$$

$$I \propto \frac{1}{\rho}$$

So,

$$\frac{I_1}{I_2} = \frac{\rho_2}{\rho_1} = \frac{8500}{6800} = \frac{5}{4}$$

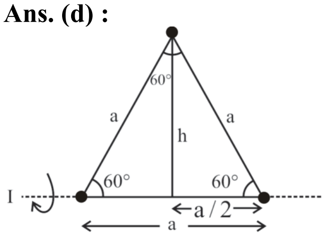
480. Three-point masses each of mass 'M' are placed at the corners of an equilateral triangle of side 'a'. The moment of inertia of this system about an axis passing through one side of a triangle is

(a) $\frac{Ma^2}{4}$ (b) $\frac{2Ma^2}{3}$

(c) $\frac{Ma^2}{3}$ (d) $\frac{3Ma^2}{4}$

MHT-CET 2020

Ans. (d) :



From Pythagoras theorem

$$a^2 = h^2 + \left(\frac{a}{2}\right)^2$$

$$h = \frac{\sqrt{3}}{2}a$$

The moment of inertia of this system about an axis passing through one side of triangle is

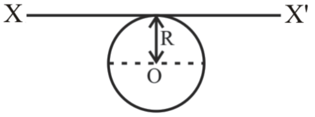
$$I = Mh^2$$

$$I = M\left(\frac{\sqrt{3}}{2}a\right)^2$$

$$I = \frac{3Ma^2}{4}$$

@apna_pdf

481. A thin wire of length 'L' and uniform linear mass density 'ρ' is bent into a circular coil with 'O' as centre. The moment of inertia of a coil about the axis XX' is

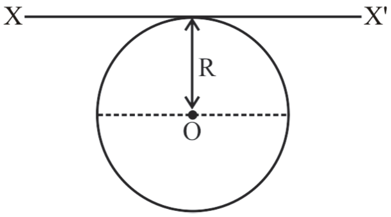


(a) $3\rho L^3/8\pi^2$ (b) $\rho L^3/4\pi^2$
(c) $3\rho L^2/4\pi^2$ (d) $\rho L^3/8\pi^2$

MHT-CET 2020
MHT- CET 2018

Ans. (a) : The moment of inertia of the loop about X X' axis is

Moment of inertia of the thin circular coil, $I = \frac{MR^2}{2}$



$$I_{XX'} = \frac{MR^2}{2} + MR^2$$

$$I_{XX'} = \frac{3}{2}MR^2$$

Where, M = mass, R = radius, ρ = linear mass density

$\because$ Mass, (M) = ρL and $R = \frac{L}{2\pi}$

$$\therefore \ I_{XX'} = \frac{3}{2}(\rho L)\left(\frac{L}{2\pi}\right)^2$$

$$I_{XX'} = \frac{3\rho L^3}{8\pi^2}$$

482. The moment of inertia of a thin uniform rod of mass 'M' and length 'L' about an axis passing through a point at a distance $\frac{L}{4}$ from one of its ends and perpendicular to the length of rod is

(a) $\frac{3ML^2}{16}$ (b) $\frac{5ML^2}{48}$
(c) $\frac{7ML^2}{48}$ (d) $\frac{9ML^2}{16}$

MHT-CET 2020

Ans. (c) : Using the parallel axis theorem–

$$I = I_{CM} + MR^2$$

$I = \frac{ML^2}{12} + M\left(\frac{L}{4}\right)^2$ [The distance from centre will also be L/4]

$$I = \frac{ML^2}{12} + \frac{ML^2}{16} = \frac{7ML^2}{48}$$

483. Two discs P and Q having equal masses and thickness but densities 'ρ_1' and 'ρ_2' respectively, are such that $\rho_1 < \rho_2$. The moment of inertia of the disc P and Q are related as

(a) $I_P = I_Q$ (b) $I_P << I_Q$
(c) $I_P < I_Q$ (d) $I_P > I_Q$

MHT-CET 2020

Ans. (d) : We know that,
Mass = volume × density
$M = (\pi R^2 t) \times \rho$ .....(i) ($\because$ t = thickness)

$$\Rightarrow R^2 = \frac{M}{\pi\rho t}$$

$\therefore$ M.I of disc, $I = \frac{MR^2}{2}$.......(ii)

From eq^n (i) and (ii), we get

$$I = \frac{M}{2} \times \frac{M}{\pi t\rho} = \frac{M^2}{2\pi t\rho}$$

$$I \propto \frac{1}{\rho}$$

For disc P density is given ρ_1 and disc Q density is ρ_2
So, $I_P > I_Q$ [$\therefore \rho_1 < \rho_2$]

484. Moment of inertia of the rod about an axis passing through the centre and perpendicular to its length is 'I_1'. The same rod is bent into a ring and its moment of inertia about the diameter is 'I_2', then $\frac{I_2}{I_1}$ is

(a) $\frac{3}{2\pi^2}$ (b) $\frac{3}{4\pi^2}$
(c) $\frac{2\pi^2}{3}$ (d) $\frac{4\pi^2}{3}$

MHT-CET 2020

Ans. (a) :

Moment of inertia of rod(I_1) = $\frac{ML^2}{12}$

When the rod is bent into a ring, then
Length of rod = Perimeter of the ring
$L = 2\pi R$

$$R = \frac{L}{2\pi}$$

Moment of inertia of a ring about its diameter

$$I_2 = \frac{MR^2}{2}$$

$$I_2 = \frac{M}{2}.\left(\frac{L}{2\pi}\right)^2 = \frac{ML^2}{8\pi^2}$$

Then,

$$\frac{I_2}{I_1} = \frac{\frac{ML^2}{8\pi^2}}{\frac{ML^2}{12}} = \frac{3}{2\pi^2}$$

$$\frac{I_2}{I_1} = \frac{3}{2\pi^2}$$

@apna_pdf

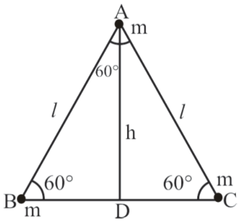
485. Three point masses, each of mass 'm' are placed at the corners of an equilateral triangle of side 'l'. The moment of inertia of the system about an axis along any one side of the triangle is

(a) ml^2 (b) $\frac{1}{3}ml^2$

(c) $\frac{3}{2}ml^2$ (d) $\frac{3}{4}ml^2$

MHT-CET 2020

Ans. (d) : Let, system rotate along side BC of equilateral triangle.



Then, moment of inertia of each of the point masses (m) at B and C about the side BC.

$(I_1) = m(0)^2 = 0$

In equilateral Δ ABC, $AD = h = \frac{\sqrt{3}}{2}l$

Then, moment of inertia of point mass m at A about the side BC we get-

$$I_2 = m(AD)^2$$

$$= m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{3}{4}ml^2$$

∴ Moment of inertia of the system about side BC

$$I = I_1 + I_1 + I_2$$

$$I = 0 + 0 + \left(\frac{\sqrt{3}}{2}l\right)^2 m$$

$$I = \frac{3ml^2}{4}$$

486. Two discs having moment of inertia I_1 and I_2 are made from same material have same mass. Their thickness and radii are t_1, t_2 and R_1, R_2 respectively. The relation between moment of inertia of each disc about an axis passing through its centre and perpendicular to its plane and its thickness is

(a) $I_1t_2^2 = I_2t_1^2$ (b) $I_1t_1 = I_2t_2$

(c) $I_1t_2 = I_2t_1$ (d) $I_1t_1^2 = I_2t_2^2$

MHT-CET 2020

Ans. (b) : Given, momentum of inertia of two discs are I_1 and I_2

∵ Moment of inertia of disc (I) $= \frac{mR^2}{2}$

So, $I_1 = \frac{mR_1^2}{2}$ and $I_2 = \frac{mR_2^2}{2}$

Therefore, $\frac{I_1}{I_2} = \frac{\frac{mR_1^2}{2}}{\frac{mR_2^2}{2}} = \frac{R_1^2}{R_2^2}$ ......(i)

∵ Mass = volume × density

Both discs have same mass and made from same material–

∴ $m_1 = m_2$

$$\rho\pi R_1^2 t_1 = \rho\pi R_2^2 t_2$$

$$\frac{R_1^2}{R_2^2} = \frac{t_2}{t_1}$$

Putting the value of these in equation (i), we get–

$$\frac{I_1}{I_2} = \frac{t_2}{t_1}$$

$$I_1t_1 = I_2t_2$$

487. Two circular rings 'A' and 'B' of radii 'nR' and 'R' are made from the same wire. The moment of inertia of 'A' about an axis passing through the centre and perpendicular to the plane of 'A' is 64 times that of the ring 'B'. The value of 'n' is

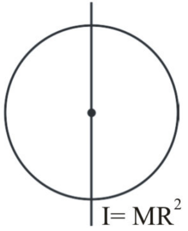
(a) 3 (b) 4

(c) 8 (d) 6

MHT-CET 2020

JIPMER-2012

Ans. (b) : Given, $I_A = 64\,I_B$, $R_A = nR$, $R_B = R$



Length of wire A = n × length of wire B

$M_A = nM_B$

∵ $I_A = M_A R_A^2$ and $I_B = M_B R_B^2$

$$\frac{I_A}{I_B} = \frac{M_A R_A^2}{M_B R_B^2} = \frac{nM_B.n^2R^2}{M_B.R^2} = 64 \qquad (\because M_A = nM_B)$$

$n^3 = 64$

$n^3 = (4)^3$

$n = 4$

488. Four particles each of mass 'M' are placed at corners of a square of side 'L'. The radius of gyration of the system about an axis perpendicular to the square and passing through its centre is

(a) $\frac{L}{\sqrt{2}}$ (b) $\frac{L}{\sqrt{8}}$

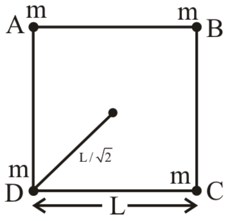
(c) $\frac{L}{\sqrt{5}}$ (d) $\frac{L}{\sqrt{3}}$

MHT-CET 2020

Ans. (a) : Length of the diagonal of the square = $\sqrt{2}L$

Half of the diagonal = $\frac{\sqrt{2}L}{2} = \frac{L}{\sqrt{2}}$

@apna_pdf



Here, $I = \sum mr^2$

$$I = 4m\left(\frac{L}{\sqrt{2}}\right)^2 = \frac{4mL^2}{2} = 2mL^2 \qquad .....(i)$$

If K is the radius of gyration, then $I = mK^2$

For four particle, $I = 4mK^2$ .....(ii)

From equation (i) and (ii), we get –

$4mK^2 = 2mL^2$

$K^2 = L^2/2$

$K = \frac{L}{\sqrt{2}}$

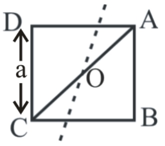
489. The moment of inertia of a uniform square plate about an axis perpendicular to its plane and passing through the centre is $\frac{Ma^2}{6}$ where M is the mass and 'a' is the side of square plate. Moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corner is

(a) $\frac{2Ma^2}{3}$ (b) $\frac{Ma^2}{3}$

(c) $\frac{3}{Ma^2}$ (d) $\frac{3Ma^2}{2}$

MHT-CET 2020

Ans. (a) : Given, side of square plate = a, mass of square = M



Moment of inertia of a square about an axis perpendicular to its plane $(I_0) = \frac{Ma^2}{6}$

In square ABCD, diagonal (AC) = $a\sqrt{2}$

Let the square is rotated about corner A

Then, $d = AO = \frac{AC}{2} = \frac{a}{\sqrt{2}}$

Thus, required moment of inertia –

$\therefore\ I_A = I_0 + md^2$

$$= \frac{Ma^2}{6} + \frac{Ma^2}{2}$$

$$= \frac{Ma^2 + 3Ma^2}{6}$$

$$= \frac{4Ma^2}{6} = \frac{2Ma^2}{3}$$

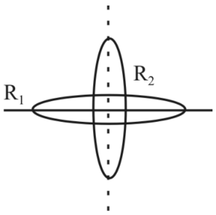
490. Two rings of same mass 'M' and radius 'R' are so placed that their centre is common and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to any one ring is

(a) $\frac{3MR^2}{2}$ (b) MR^2

(c) $\frac{2MR^2}{3}$ (d) $\frac{MR^2}{2}$

MHT-CET 2020

Ans. (a) :



As we know, the moment of inertia of a rotating system depends on mass and distribution of mass with respect to its axis of rotation.

$\therefore \quad I = MR^2$

For first ring moment of inertia about an axis passing through its centre and perpendicular to its axis –

$I_1 = MR^2$

The other ring is perpendicular to the first. So, its axis becomes the diameter of first and moment of inertia of a ring about its diameter –

$$I_2 = \frac{MR^2}{2}$$

Total moment of inertia $= MR^2 + \frac{MR^2}{2} = \frac{3}{2}MR^2$

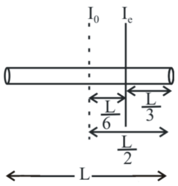
497. A thin uniform rod has mass 'M' and length 'L'. The moment of inertia about an axis perpendicular to it and passing through the point at a distance $\frac{L}{3}$ from one of its ends, will be

(a) $\frac{ML^2}{3}$ (b) $\frac{ML^2}{9}$

(c) $\frac{ML^2}{12}$ (d) $\frac{7}{8}ML^2$

MHT-CET 2020
MHT-CET 2010

Ans. (b) :



According to theorem of parallel axis moment of inertia of rod (length L) about its axis passing through the center $(I_0) = \frac{ML^2}{12}$

@apna_pdf

Moment of inertia of rod at its end

$$I_e = I_0 + M\left(\frac{L}{6}\right)^2$$

$$= \frac{1}{12}ML^2 + \frac{ML^2}{36}$$

$$I_e = \frac{4ML^2}{36} = \frac{ML^2}{9}$$

492. The ratio of radii of gyration of a ring to a disc (both circular) of same radii and mass, about a tangential axis perpendicular to the plane is

(a) $\frac{2}{\sqrt{5}}$ (b) $\frac{\sqrt{3}}{\sqrt{2}}$

(c) $\frac{2}{\sqrt{3}}$ (d) $\frac{\sqrt{2}}{1}$

MHT-CET 2020
NEET-2013

Ans. (c) : Let, Radius of ring = Radius of disc = R, mass of ring = Mass of disc = M

Moment of inertia of ring about tangential axis the perpendicular to its axis

$$I_R = MR^2 + Mh^2 = MR^2 + MR^2 = 2MR^2$$

$$I_D = \frac{1}{2}MR^2 + Mh^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

Let K_R and K_D are radius of gyration of ring and disc

Then, $I_R = MK_R^2 = 2MR^2$

$\therefore \quad K_R = \sqrt{2}\ R$

Now, $I_D = MK_D^2 = \frac{3}{2}MR^2$

$$K_D = \sqrt{\frac{3}{2}}\ R$$

$$\therefore \frac{K_R}{K_D} = \frac{\sqrt{2}R}{\frac{\sqrt{3}}{\sqrt{2}}R} = \frac{2}{\sqrt{3}}$$

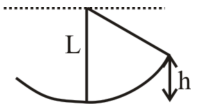
493. A thin, uniform metal rod of mass 'M' and length 'L' is swinging about a horizontal axis passing through its end. Its maximum angular velocity is 'ω'. Its centre of mass rises to a maximum height of (g = acceleration due to gravity)

(a) $\frac{L^2\omega^2}{3g}$ (b) $\frac{L^2\omega^2}{3}$

(c) $\frac{L^2\omega^2}{2g}$ (d) $\frac{L^2\omega^2}{6g}$

MHT-CET 2020

Ans. (d) :



According to law of conservation of energy–

$$\frac{1}{2}I\omega^2 = Mgh \qquad \text{........(i)}$$

Moment of inertia of the rod about the axis passing through its end

$$I = \frac{1}{3}ML^2$$

Putting the value of 'I' in equation (i), we get –

$$\frac{1}{2}\left(\frac{1}{3}ML^2\right).\omega^2 = Mgh$$

$$h = \frac{L^2\omega^2}{6g}$$

494. Moment of inertia of a uniform solid sphere of mass 'M' and radius 'R' about an axis at a distance $\left(\frac{R}{2}\right)$ from the centre is

(a) $\frac{2}{5}MR^2$ (b) $\frac{9}{10}MR^2$

(c) $\frac{13}{20}MR^2$ (d) $\frac{7}{5}MR^2$

MHT-CET 2020

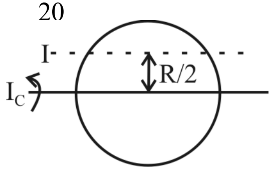
Ans. (c) : From parallel axis theorem

$$I = I_C + Md^2$$

$$I = I_C + M\left(\frac{R}{2}\right)^2$$

$$= \frac{2}{5}MR^2 + \frac{MR^2}{4}$$

$$= \frac{13}{20}MR^2$$



495. Four spheres each of mass 'M' and radius 'R' are placed with their centers on the corners of a square of side 'L'. The moment of inertia of the system about any side of square is

(a) $\frac{6}{5}MR^2 + ML^2$ (b) $\frac{3}{5}MR^2 + 2ML^2$

(c) $\frac{8}{5}MR^2 + 2ML^2$ (d) $\frac{4}{3}MR^2 + ML^2$

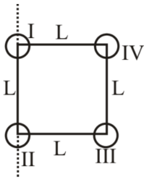
MHT-CET 2020

Ans. (c) : Given,

Mass of each sphere = M

Radius = R

distance between two sphere = L



Now as we know moment of inertia of a sphere lying on the axis $= \frac{2}{5}MR^2$

@apna_pdf

So, moment of inertia of two sphere lying on the axis

$$= 2\times\frac{2}{5}MR^2 = \frac{4}{5}MR^2$$

By using parallel axis theorem of moment of inertia of another two sphere lying on the line parallel to the axis at distance of L $= 2\left[\frac{2}{5}MR^2 + ML^2\right]$

$$= \frac{4}{5}MR^2 + 2ML^2$$

Total moment of inertia $= \frac{4}{5}MR^2 + \left(\frac{4}{5}MR^2 + 2ML^2\right)$

$$= \frac{8}{5}MR^2 + 2ML^2$$

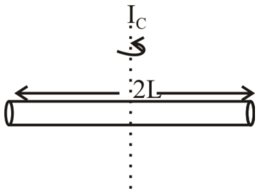
496. A uniform rod of length '2L' has constant mass per unit length 'm'. Moment of inertia of the rod about an axis passing through its centre and perpendicular to length is

(a) $\frac{mL^3}{3}$ (b) $\frac{mL^2}{4}$

(c) $\frac{2mL^3}{3}$ (d) $\frac{mL^2}{12}$

MHT-CET 2020

Ans. (c) :



Given,

length of rod (l) = 2 L

Mass of rod (m) = 2mL

Moment of inertia of rod about the axis passing through its center $(I_C) = \frac{1}{12}ml^2$

$$I_C = \frac{1}{12}(2mL).(2L)^2$$

$$= \frac{8}{12}mL^3$$

$$= \frac{2}{3}mL^3$$

497. A uniform disc of mass 4 kg has radius of 0.4 m. Its moment of inertia about an axis passing through a point on its circumference and perpendicular to its plane is

(a) 0.32 kg-m^2 (b) 0.96 kg-m^2

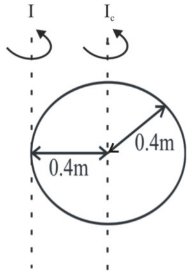
(c) 0.16 kg-m^2 (d) 0.64 kg-m^2

MHT-CET 2020

Ans. (b) : Given,

Mass of disc = 4 kg

radius = 0.4m



Moment of Inertia of disc about the centroid

$$I_c = \frac{1}{2}MR^2$$

Moment of inertia of disc about the axis passing through a point on its circumference,

from parallel axis theorem

$I = I_C + MR^2$

$$I = \frac{1}{2}MR^2 + MR^2$$

$$= \frac{3}{2}MR^2 = \frac{3}{2}\times 4\times(0.4)^2$$

$$= 6\times 0.16$$

$$= 0.96 \text{ kg. m}^2$$

498. A circular disc 'X' of radius 'R' made from iron plate of thickness 't' has moment of inertia 'I_x' about an axis passing through the centre of disc and perpendicular to its plane. Another disc 'Y' of radius '3R' made from an iron plate of thickness $\left(\frac{t}{3}\right)$ has moment of inertia 'I_y' about the axis same as that of disc X. The relation between I_x and I_y is

(a) $I_y = 9I_x$ (b) $I_y = I_x$

(c) $I_y = 3I_x$ (d) $I_y = 27I_x$

MHT-CET 2020

Ans. (d) : Mass = volume ×density

Radius of disc X = R

So, mass of disc X (M_x) = (πR^2.t)ρ

Radius of disc Y = 3R and thickness of disc Y = t/3

So, mass of disc Y (M_y) $= \left[\pi(3R)^2\frac{t}{3}\right]\rho$

$$= (3\pi R^2 t)\rho$$

Moment of inertia of disc about an axis passing through center and perpendicular to the plane $I = \frac{MR^2}{2}$

So, $I_x = \frac{M_x R^2}{2}$

$$= \frac{(\pi R^2.t)\rho.R^2}{2} = \frac{1}{2}\pi R^4 t.\rho$$

@apna_pdf

$$I_y = \frac{M_y(3R)^2}{2}$$

$$= \frac{(3\pi R^2.t)\rho.9R^2}{2} = \frac{27}{2}\pi R^4 t.\rho$$

$$\frac{I_x}{I_y} = \frac{\frac{1}{2}\pi R^4 t.\rho}{\frac{27}{2}\pi R^4 t.\rho}$$

$$I_y = 27 I_x$$

499. Two rings of radii R and nR made from the same wire have the ratio of moments of inertia about an axis passing through their centre and perpendicular to the plane of the rings is 1 : 8. The value of n is

(a) $2\sqrt{2}$ (b) 2

(c) 4 (d) $\frac{1}{2}$

MHT-CET 2020

Ans. (b) : Given,

$R_1 = R$, $R_2 = nR$, $I_1 : I_2 = 1 : 8$

$m_1 = (2\pi R.t.\rho)$

$m_2 = (2\pi nR.t.\ \rho)$

$\because\ I = MR^2$

$$\therefore \frac{I_1}{I_2} = \frac{m_1R_1^2}{m_2R_2^2}$$

$$\frac{1}{8} = \frac{(2\pi R.t.\rho).R^2}{(2\pi nR.t.\rho).(nR)^2}$$

$$\frac{1}{8} = \frac{1}{n^3}$$

$$\frac{1}{2^3} = \frac{1}{n^3}$$

$n = 2$

500. The torque necessary to produce an angular acceleration of 25 rad. s^{-2} in a flywheel of mass 50 kg and radius of gyration 50 cm about its axis is

(a) 312.5 dyne. cm (b) 31.25 N. m

(c) 31.25 dyne. cm (d) 312.5 N. m

AP EAMCET-25.09.2020, Shift-II

Ans. (d) : Given that,

Radius (R) = 50 cm = 1/2 m

Angular acceleration (α) = 25 rad/sec^2

Mass (M) = 50 kg

Moment of inertia = MR^2

= 50 ×(1/2)^2 = 50/4 kgm^2

We know that,

Torque = Iα

Torque = 50/4 × 25 = 1250/4 = 312.5 N.m

501. The moment of inertia of a slab about a perpendicular axis passing through in centre is M $\left(\frac{a^2+b^2}{12}\right)$. The value of radius of Gyration, K is

(a) $\frac{(a^2+b^2)^{1/2}}{2\sqrt{3}}$ (b) $\frac{a^2+b^2}{12}$

(c) $\frac{\sqrt{a+b}}{5}$ (d) $\frac{2}{5}\sqrt{a^2+b^2}$

Assam CEE-2020

Ans. (a) : Given that,

Moment of inertia of a slab about a perpendicular axis passing through in centre is –

$$I = M\left(\frac{a^2+b^2}{12}\right) \qquad \text{....(i)}$$

Then, we know that,

$$I = MK^2 \qquad \text{....(ii)}$$

Where K is radius of gyration

From equation (i) and (ii), we get

$$MK^2 = M\left(\frac{a^2+b^2}{12}\right)$$

$$K = \frac{(a^2+b^2)^{1/2}}{2\sqrt{3}}$$

502. The moment of inertia of a circular ring of radius 15 cm and mass 150 g is _____

(a) 0.008 kg.m^2 (b) 0.006 kg.m^2

(c) 0.004 kg.m^2 (d) 0.003 kg. m^2

AP EAMCET-24.09.2020, Shift-II

Ans. (d): Given, m = 150 gram = 0.15 kg

r = 15 cm = 0.15 m

For circular ring

$I = mr^2$

$I = 0.15\ (0.15)^2 = 15 \times 225 \times 10^{-6}$

$I = 0.003$ kg. m^2

503. The masses of 200 g and 300 g are attached to the 20 cm and 70 cm marks of a light meter rod respectively. The moment of inertia of the system about an axis passing through 50 cm mark is

(a) 0.15 kg m^2 (b) 0.036 kg m^2

(c) 0.3 kg m^2 (d) zero

COMEDK 2020

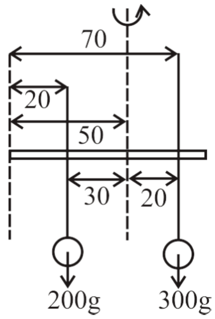
Ans. (b) : Given,

m_1 = 200g = 0.2kg

m_2 = 300g = 0.3kg

r_1 = 20cm = 0.2m

r_2 = 30cm = = 0.3m



The moment of inertia about axis passing through 50cm mark,

@apna_pdf

$\because I = \sum mr^2$

$I_{50} = m_1 r_1^2 + m_2 r_2^2$

$= 0.2 \times (0.3)^2 + 0.3 \times (0.2)^2$

$= 0.2 \times 0.09 + 0.3 \times 0.04$

$= 0.018 + 0.012$

$I_{50} = 0.03\ \text{kgm}^2$

504. Four particles each of the mass m are placed at the corners of a square of side length *l*, the radius of gyration of the system about an axis perpendicular to the square and passing through its centre is

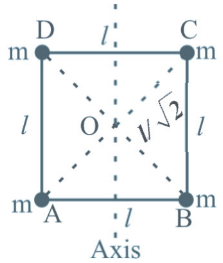
(a) $\frac{l}{\sqrt{2}}$ (b) $\frac{l}{2}$

(c) l (d) $\sqrt{2}\,l$

COMEDK 2020

Ans. (a) : The distance of the particle from the centre of square, AC = $\sqrt{2}l$

$OC = \frac{\sqrt{2}l}{2} = \frac{l}{\sqrt{2}}$



Given, M = 4m

MOI of system, I = $\sum mr^2$

$= 4m\left(\frac{l}{\sqrt{2}}\right)^2$

$= \frac{4ml^2}{2}$

$I = 2ml^2$

And the radius of gyration,

$K = \sqrt{\frac{I}{M}} = \sqrt{\frac{2ml^2}{4m}}$

$\therefore \quad K = \frac{l}{\sqrt{2}}$

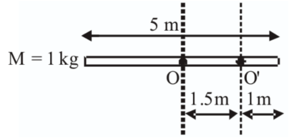
505. Consider a thin metal strip of mass 1kg and length 5m. Calculate its moment of inertia about an axis perpendicular to strip and located at 100cm on strip from one its end. (Assume the breadth as the strip is negligible)

(a) 4.33 kg-m^2 (b) 4.85 kg-m^2

(c) 4.11 kg-m^2 (d) 4.66 kg-m^2

TS-EAMCET.11.09.2020, Shift-2

Ans. (a) : The given situation is as shown below,



Here, O is the point where centre of mass of whole strip exist.

The point O' is 100 cm or 1 m away from one end. So, its distance from centre of mass or from point O is 1.5 m

∴ Moment of inertia about an axis perpendicular to strip at point O' can be calculated using parallel axis theorem as

$$I' = I_{CM} + MR^2$$

$$= \frac{ML^2}{12} + MR^2$$

$$= \frac{1 \times 5 \times 5}{12} + 1 \times 1.5 \times 1.5$$

$$= 2.08 + 2.25$$

$$= 4.33\ \text{kg-m}^2$$

506. A rod of length L is composed of a uniform length $\frac{L}{2}$ of wood whose mass is m_w and an uniform length $\frac{L}{2}$ of brass whose mass is m_b. The moment of inertia I of the rod about an axis perpendicular to the rod and through its centre is equal to

(a) $(m_w + m_b)\frac{L^2}{6}$ (b) $(m_w + m_b)\frac{L^2}{2}$

(c) $(m_w + m_b)\frac{L^2}{12}$ (d) $(m_w + m_b)\frac{L^2}{3}$

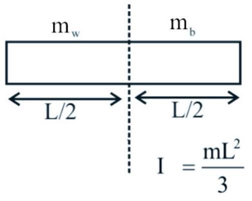
Manipal UGET- 2020

CG PET- 2014

Ans. (c) : Length of Rod=L

Mass of wood = m_w

Mass of brass = m_b



At the moment of inertia of uniform rod about axis passing through the end (I) = $\frac{mL^2}{3}$

For wood $I_w = \frac{m_w\left[\frac{L}{2}\right]^2}{3}$

For brass $I_b = \frac{m_b\left[\frac{L}{2}\right]^2}{3}$

@apna_pdf

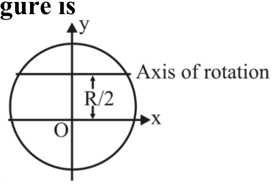
Moment of inertia of system $(I_s) = I_w + I_b$

$$= \frac{m_w \cdot \left(\frac{L}{2}\right)^2}{3} + \frac{m_b \cdot \left(\frac{L}{2}\right)^2}{3}$$

$$= \frac{m_w L^2}{12} + \frac{m_b L^2}{12}$$

$$I = \frac{L^2}{12}(m_w + m_b)$$

507. M.I of a circular loop of radius R about the axis in figure is



(a) MR^2 (b) $(3/4)\ MR^2$
(c) $MR^2/2$ (d) $2MR^2$

BITSAT-2020

Ans. (b) : Moment of inertia of ring about diameter passing through point 'O' $(I_o) = \frac{MR^2}{2}$

By parallel axis theorem,

$$I = I_o + Md^2$$

$$I = \frac{MR^2}{2} + M\left(\frac{R}{2}\right)^2$$

$$I = \frac{3}{4}MR^2$$

508. If the radius of a sphere is doubled by keeping its mass constant, compare the moment of inertia of the old sphere with that of the new sphere, about any diameter.

(a) $I_1 : I_2 = 1 : 4$ (b) $I_1 : I_2 = 1 : 2$
(c) $I_1 : I_2 = 4 : 1$ (d) $I_1 : I_2 = 2 : 1$

AP EAMCET (23.09.2020) Shift-I

Ans. (a) : Given,
$R_2 = 2R_1$, $M_1 = M_2 =$ constant
As we know that,
Moment of inertia of a solid sphere about its diameter is

$$I = \frac{2}{5}MR^2$$

Moment of inertia of the old sphere,

$$I_1 = \frac{2}{5}M_1R_1^2 \quad \ldots\ldots.(i)$$

Moment of inertia of the new sphere,

$$I_2 = \frac{2}{5}M_2R_2^2$$

$$I_2 = \frac{2}{5}M_1(2R_1)^2 \quad .....(ii)$$

From equation (i) and (ii), we get,

$$\frac{I_1}{I_2} = \frac{\frac{2}{5}M_1R_1^2}{\frac{2}{5}M_1(2R_1)^2} = \frac{1}{4}$$

$$\therefore \quad I_1 : I_2 = 1 : 4$$

509. A body of mass 5 kg acquires an acceleration of 10 rads^{-2} due to an applied torque of 2 Nm. Its radius of gyration is

(a) 2.5 m (b) $\sqrt{2.5}$m
(c) $\sqrt{0.2}$ (d) 0.2 m

AP EAMCET (21.09.2020) Shift-I

Ans. (d) : Given,
Mass of body (m) = 5 kg
Angular acceleration (α) = 10 rad/s^2
Torque (τ) = 2 N.m
Now,

$$\tau = I \times \alpha$$

$$\therefore \quad I = \frac{\tau}{\alpha} = \frac{2}{10} = 0.2\ \text{kg.m}^2$$

Now, $I = mk^2$ [∵ k = radius of gyration]

Radius of gyration $(k) = \sqrt{\frac{I}{m}}$

$$k = \sqrt{\frac{0.2}{5}} = \frac{1}{5}$$

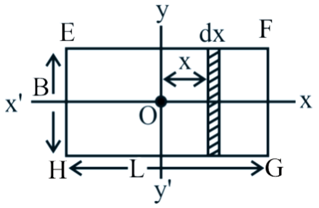
$$k = 0.2\,\text{m}$$

510. The moment of inertia of a rectangular plate of mass M, length L and breadth B, about an axis passing through its centre and perpendicular to its plane is

(a) $\frac{M(L+B)}{12}$ (b) $\frac{M(L^2)}{12}$
(c) $\frac{M(L^2+B^2)}{12}$ (d) $\frac{M(B^2)}{12}$

AP EAMCET (21.09.2020) Shift-I

Ans. (c) :



Rectangular EFGH of length (L), breadth (B) and mass (M),
Now, differentiate the area,

$$dA = B.dx \qquad \left(\because \sigma = \frac{M}{A}\right)$$

$$\sigma = \frac{M}{L \times B} \qquad \text{Where, } \sigma = \text{Mass per unit area}$$

So, $$dM = \sigma dA = \frac{M.B.dx}{L.B}$$

$$= \frac{M.dx}{L}$$

Now, integrating the values,

$$\int dI_x = \int_{-L/2}^{L/2} dM \times x^2$$

$$I_x = \frac{M}{L}\int_{-L/2}^{L/2} x^2 dx$$

@apna_pdf

$$I_x = \frac{M}{L}\left[\frac{x^3}{3}\right]_{-L/2}^{L/2}$$

$$I_x = \frac{M}{L}\left[\frac{L^3}{24}+\frac{L^3}{24}\right] = \frac{M}{L}\times\frac{L^3}{12}$$

$$I_x = \frac{ML^2}{12}$$

Same as for, $I_y = \dfrac{MB^2}{12}$

Using perpendicular axis theorem,

$$I_z = I_x + I_y$$

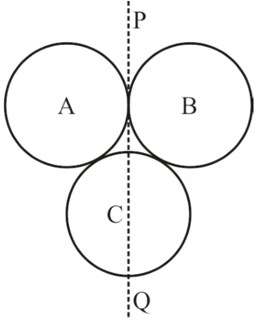
$$I_z = \frac{ML^2}{12}+\frac{MB^2}{12} = \frac{M(L^2+B^2)}{12}$$

For a rectangular rod,

$$I = \Sigma M\left(\frac{L^2+B^2}{12}\right)$$

$$\therefore \quad I = M\left(\frac{L^2+B^2}{12}\right)$$

511. Three identical uniform solid spheres each of mass m and radius r are joined as shown in the figure, with centres lying in the same plane. The moment of inertia of the system about an axis lying in that plane and passing through the centre of sphere C is

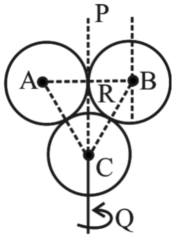


(a) $\dfrac{16}{5}mr^2$ (b) $\dfrac{12}{5}mr^2$

(c) $4mr^2$ (d) $\dfrac{3}{5}mr^2$

AP EAMCET (17.09.2020) Shift-I

Ans. (a) : Given,



Mass of solid sphere = m

Radius of solid sphere = r

We know that,

$$I_{sphere} = \frac{2}{5}mr^2$$

Moment of inertia of solid spheres passing through center-

$$I_C = \frac{2}{5}mr^2$$

Moment of inertia of a solid spheres through its tangent is given by

$$I_A = I_B = \frac{2}{5}mr^2 + mr^2$$

$$I_A = I_B = \frac{7}{5}mr^2$$

Net moment of inertia of the system-

$$I_{PQ} = I_A + I_B + I_C$$

$$I_{PQ} = \frac{7}{5}mr^2 + \frac{7}{5}mr^2 + \frac{2}{5}mr^2$$

$$I_{PQ} = \frac{16}{5}mr^2$$

512. Four point masses, each of mass M are placed at the corners of a square of side L. The moment of inertia of the system about one of its diagonals is

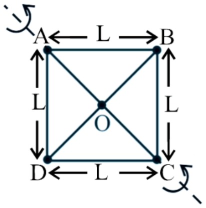
(a) $2ML^2$ (b) ML^2

(c) $4ML^2$ (d) $6ML^2$

AP EAMCET (17.09.2020) Shift-I

Ans. (b) : Given, mass of each point = M

Side of square = L



AB = BC = CD = DA = L

Length of diagonal,

$$BD = \sqrt{DA^2+AB^2} = \sqrt{L^2+L^2}$$

$$BD = \sqrt{2L^2}$$

$$BD = L\sqrt{2}$$

$$\therefore \quad OD = OB = \frac{BD}{2} = \frac{L\sqrt{2}}{2} = \frac{L}{\sqrt{2}}$$

Moment of inertia of given system about the diagonal (AC),

$$I_{AC} = I_A + I_B + I_C + I_D$$

$$I_{AC} = 0 + M\left(\frac{L}{\sqrt{2}}\right)^2 + 0 + M\left(\frac{L}{\sqrt{2}}\right)^2$$

$$I_{AC} = \frac{ML^2}{2}+\frac{ML^2}{2}$$

$$I_{AC} = ML^2$$

513. A solid cylinder of mass 2 kg and radius 4 cm is rotating about its axis at the rate of 3 rpm. The torque required to stop after 2π revolutions is

(a) 2×10^{-3} N-m (b) 12×10^{-4} N-m

(c) 2×10^{6} N-m (d) 2×10^{-6} N-m

NEET (National) - 2019

@apna_pdf

Ans. (d) : Given that,
Mass (m) = 2 kg
Radius (r) = 4 cm ⇒ 0.04 m

Rate of rotation (ω) = 3 rpm $= 3\times\frac{2\pi}{60} \Rightarrow \frac{\pi}{10}$

Moment of inertia $= \frac{1}{2}mr^2 = \frac{1}{2}\times 2\times(0.04)^2$
$= 16 \times 10^{-4}$ kgm^2
$= 1.6 \times 10^{-3}$ kgm^2

Angular displacement = 2π× revolution
$= 2\pi \times 2\pi = 4\pi^2$

From conservation of energy theorem,
Change in rotational kinetic energy = torque × angular displacement

So, $\frac{1}{2}I\omega^2 = \text{torque}\times 4\pi^2$

$$\frac{1}{2}\times 1.6\times 10^{-3}\times\left(\frac{\pi}{10}\right)^2 = \tau\times 4\pi^2$$

$$\tau = \frac{\frac{1}{2}\times 1.6\times 10^{-3}\times\left(\frac{\pi}{10}\right)^2}{4\pi^2}$$

torque (τ) = 2 × 10^{-6} N-m

514. When a 12000 joule of work is done on a flywheel, its frequency of rotation increases from 10Hz to 20Hz. The moment of inertia of flywheel about its axis of rotation is $(\pi^2 = 10)$

(a) 1.688 kgm^2
(b) 2 kgm^2
(c) 1.5 kgm^2
(d) 1 kgm^2

MHT-CET 2019

Ans. (b) : Given, work done on a flywheel (W) = 12000 Joule, initial frequency (f_1) = 10 Hz, final frequency (f_2) = 20 Hz

∴ Angular velocity for rotational motion-
$\omega_1 = 2\pi f_1 = 2\pi \times 10 = 20\pi$
And $\omega_2 = 2\pi \times 20 = 40\pi$

Acording to work energy theorem–
Work done on a flywheel = Change in rotational kinetic energy

$$W = \frac{1}{2}I\left(\omega_2^2 - \omega_1^2\right)$$

Where, I = Moment of inertia

$$12000 = \frac{1}{2}I\left[(40\pi)^2 - (20\pi)^2\right]$$

$$\therefore \quad 12000 = \frac{1}{2}I(1600 - 400)\pi^2$$

$$I = \frac{12000\times 2}{12000} \quad \left[\because \pi^2 = 10\right]$$

$$I = 2\text{kgm}^2$$

515. A thin ring having mass 100 g and radius 10 cm is rotating about its axis with frequency 1 Hz. Four objects each of mass 12.5 g are kept gently to the opposite ends of two perpendicular diameters of the ring. The new frequency of rotation of the ring will be

(a) $\frac{4}{3}$Hz
(b) $\frac{2}{3}$Hz
(c) $\frac{3}{2}$Hz
(d) $\frac{3}{4}$Hz

MHT-CET 2019

Ans. (b) : Given that, mass of ring (M) = 100 g = 10^{-1} kg, radius of ring (R) = 10 cm = 10^{-1}m, f_1 = 1 Hz

∵ Angular velocity (ω)= 2πf
$\omega_1 = 2\pi \times 1 = 2\pi$

Initial moment of inertia of ring (I_1) = MR^2
$= 10^{-1} \times (10^{-1})^2$
$= 10^{-3}$ kg m^2

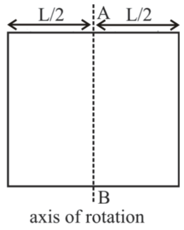
After putting four objects each of mass 12.5 g or 125×10^{-4} kg

Moment of inertia (I_2) = MR^2 + 4× mR^2
$= 10^{-1}\times (10^{-1})^2 + 4 \times 125 \times 10^{-4} \times (10^{-1})^2$
$= 10^{-3} + 500 \times 10^{-6}$
$= 1.5 \times 10^{-3}$ kg-m^2

According to law of conservation of angular momentum–
$L_1 = L_2$
i.e. $I_1\,\omega_1 = I_2\,\omega_2$
$10^{-3} \times 2\pi = 1.5\times 10^{-3} \times 2\pi\, f_2$

$$f_2 = \frac{1}{1.5} = \frac{2}{3}\text{Hz}$$

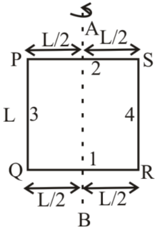
516. Four metal rods each of mass 'M' and length 'L' are welded to form of a square as shown. What is M.I. of the system about axis 'AB'?



(a) $\frac{2}{3}$ML^2
(b) $\frac{ML^2}{6}$
(c) $\frac{ML^2}{3}$
(d) $\frac{ML^2}{2}$

MHT-CET 2019

Ans. (a) : Given, mass of each rod = M
length of each rod = L



We know that, moment of inertia of the rod about its axis-

$$I = \frac{1}{12}ML^2$$

@apna_pdf

So, moment of inertia about rod 1 and rod 2 are $\frac{ML^2}{12}$

$$\therefore \quad I_1 + I_2 = \frac{1}{12}ML^2 + \frac{1}{12}ML^2 = \frac{1}{6}ML^2$$

Rod 3 and rod 4 are at distance L/2 from the axis of rotation and parallel to axis of rotation.

$$\therefore \quad I_3 + I_4 = M\left(\frac{L}{2}\right)^2 + M\left(\frac{L}{2}\right)^2$$

$$= 2M\frac{L^2}{4} = \frac{1}{2}ML^2$$

Total moment of inertia of the system about axis 'AB'

$$= (I_1 + I_2) + (I_3 + I_4)$$

$$= \frac{1}{6}ML^2 + \frac{1}{2}ML^2$$

$$= \frac{4}{6}ML^2$$

$$= \frac{2}{3}ML^2$$

517. Three identical rods each of mass 'M' and length 'L' are joined to form a symbol 'H'. The moment of inertia of the system about one of the sides of 'H' is

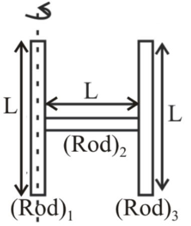
(a) $ML^2/6$ (b) $4ML^2/3$

(c) $2ML^2/3$ (d) $ML^2/2$

MHT-CET 2019

Ans. (b) : Given, Mass of each rod = M

length of each rod = L



As, the axis of rotation passed through the rod. Therefore moment of inertia of $(Rod)_1 = (I_1) = 0$

The axis of rotation passes from end point of the $(Rod)_2$.

$$\therefore \quad I_2 = \frac{1}{3}ML^2$$

For $(Rod)_3$ using parallel axis theorem,

$$I_3 = I_{cm} + I_{\text{at } L}$$

$$I_3 = 0 + ML^2$$

or $I_3 = ML^2$

Now, Total moment of inertia of the system

$$(I) = I_1 + I_2 + I_3$$

$$= 0 + \frac{1}{3}ML^2 + ML^2$$

$$= \frac{4}{3}ML^2$$

518. If radius of the solid sphere is doubled by keeping its mass constant, the ratio of their moment of inertia about any of its diameter is

(a) 1 : 4 (b) 2 : 3

(c) 2 : 5 (d) 1 : 8

MHT-CET 2019

Ans. (a) : Moment of inertia of a solid sphere about its diameter $(I) = \frac{2}{5}mR^2$ ....(i)

If the radius of a solid sphere is doubled then the new moment of inertia of sphere,

$$I' = \frac{2}{5}m(2R)^2 = \frac{8}{5}mR^2 \quad \text{....(ii)}$$

Dividing equation (i) by (ii), we get–

$$\frac{I}{I'} = \frac{\frac{2}{5}mR^2}{\frac{8}{5}mR^2} = \frac{1}{4}$$

The ratio of their moment of inertia about any of its diameter is 1: 4.

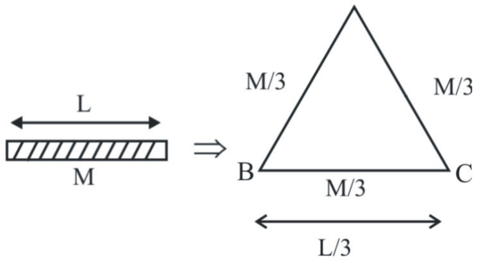
519. A uniform bar of mass M and length L is bent in the form of an equilateral triangle. Find the moment of inertia of the triangle about an axis passing through the centre of mass and perpendicular to the plane of the triangle

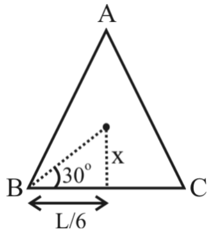
(a) ML^2 (b) $ML^2/2$

(c) $ML^2/27$ (d) $ML^2/54$

J&K-CET-2019

Ans. (d):





$$\tan 30^\circ = \frac{x}{L/6} \Rightarrow \frac{1}{\sqrt{3}} = \frac{x}{L/6}$$

$$x = \frac{L}{6\sqrt{3}}$$

Apply parallel axis theorem,

$$I_{Net} = I_G + mx^2$$

$$= \left[\frac{1}{12} \times \frac{M}{3}\left(\frac{L}{3}\right)^2 + \frac{M}{3}\left(\frac{L}{6\sqrt{3}}\right)^2\right] \times 3$$

$$= \left[\frac{M}{36} \times \frac{L^2}{9} + \frac{M}{3} \times \frac{L^2}{36 \times 3}\right] \times 3$$

$$= \frac{ML^2}{108} + \frac{ML^2}{108} = \frac{2ML^2}{108}$$

$$I_{Net} = \frac{ML^2}{54}$$

@apna_pdf

520. A long cylindrical rod is welded to a thin circular disc of diameter 0.5 m at a point on its circumference. The rod is in the same plane as that of the disc and forms a tangent to the disc. The radius of gyration of the disc about the rod (in m) is

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{5}}{8}$

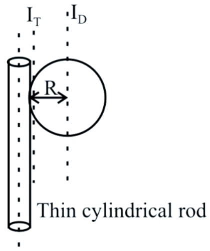
(c) $\frac{1}{2}$ (d) $2\sqrt{2}$

TS-EAMCET-03.05.2019, Shift-2

Ans. (b) :

Given, diameter of disc = 0.5 meter

$\therefore$ Radius of disc = $\frac{0.5}{2}=\frac{1}{4}$ m



Moment of inertia of a disc about its diameter,

$$I_{CG}=\frac{MR^2}{4}$$

Moment of inertia of a disc about a tangent passing through circumference and parallel to its diameter.

$$I=\frac{MR^2}{4}+MR^2=\frac{5MR^2}{4}$$

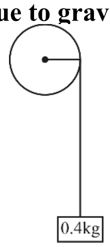
$$\therefore MK^2=\frac{5}{4}MR^2 \qquad [\because I=MK^2]$$

$$K^2=\frac{5}{4}R^2$$

$$K=\sqrt{\frac{5}{4}}\times\frac{0.5}{2} \quad =\frac{\sqrt{5}}{2}\times\frac{1}{4}$$

$$K=\frac{\sqrt{5}}{8}\text{m}$$

521. A wheel of radius 8 cm is attached to a support so as to rotate about a horizontal axis through its centre. A string of negligible mass wrapped around its circumference carries a mass of 0.4 kg attached to its free end. When the mass is released, its descends through 1 m in 10 seconds, then its moment of inertia is (Acceleration due to gravity, g = 10 ms^{-2})



(a) 1.277 kg m^2 (b) 2.177 kg m^2

(c) 21.77 kg m^2 (d) 12.77 kg m^2

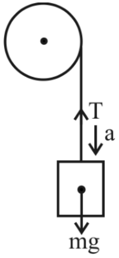
AP EAMCET (23.04.2019) Shift-I

Ans. (a) : Given,

Radius of wheel (r) = 8 cm = 8 × 10^{-2} m,

Mass of body (m) = 0.4 kg

Descending length (s) = 1 m, Time (t) = 10 sec.



From second law of motion.

$$s=ut+\frac{1}{2}at^2$$

$$1=0+\frac{1}{2}a\times(10)^2 \qquad a=\frac{1}{50}\text{m/s}^2$$

Angular acceleration,

$$\alpha=\frac{a}{r} \qquad [\because a=\alpha r]$$

$$\alpha=\frac{\frac{1}{50}}{8\times10^{-2}}$$

$$\alpha=\frac{100}{50\times8}$$

$$\alpha=\frac{1}{4}\text{rad/s}^2$$

Velocity after 10 sec,

$$v=u+at$$

$$v=0+\frac{1}{50}\times10$$

$$v=0.2\text{m/s}$$

Angular velocity,

$$\omega=\frac{v}{r} \qquad [\because v=r\omega]$$

$$\omega=\frac{0.2}{8\times10^{-2}}=\frac{20}{8}$$

$$\omega=\frac{5}{2}\text{rad/s}$$

From law of conservation of energy,

Loss of P.E. = K.E. of translation + K.E. of rotation

$$mgh=\frac{1}{2}mv^2+\frac{1}{2}I\omega^2$$

$$0.4\times10\times1=\frac{1}{2}\times0.4\times(0.2)^2+\frac{1}{2}\times I\times\left(\frac{5}{2}\right)^2$$

$$4=(0.2\times0.04)+\frac{1}{2}\times I\times\frac{25}{4}$$

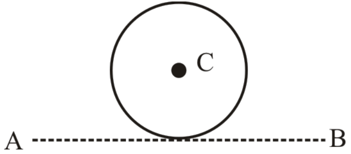
$$4-0.008=3.125I$$

$$3.992=3.125I$$

$$I=\frac{3.992}{3.125}=1.277\text{ kg-m}^2$$

@apna_pdf

522. A thin wire of length l having a linear density ρ is bent into a circular loop with C as its centre as shown in the figure. The moment of inertia of the loop about the line AB is



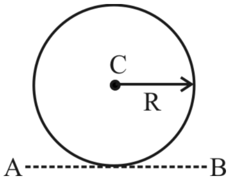
(a) $\frac{5}{16}\frac{\rho l^3}{\pi^3}$ (b) $\frac{1}{16}\frac{\rho l^3}{\pi^3}$

(c) $\frac{1}{8}\frac{\rho l^3}{\pi^3}$ (d) $\frac{3}{8}\frac{\rho l^3}{\pi^2}$

AP EAMCET (22.04.2019) Shift-I

Ans. (d) : Given,
Length of thin wire = l
Linear density of thin wire = ρ
Mass of thin wire, (M) = $l\rho$
Circumference = length of thin wire

$$2\pi R = l$$
$$R = \frac{l}{2\pi}$$



The moment of inertia of a thin loop about it's diameter,

$$I = \frac{1}{2}MR^2$$
$$I = \frac{1}{2}l\rho \times \left(\frac{l}{2\pi}\right)^2$$
$$I = \frac{l^3\rho}{8\pi^2}$$

Now using parallel axis theorem,

$$I_{AB} = I_C + MR^2$$
$$I_{AB} = \frac{l^3\rho}{8\pi^2} + l\rho \times \left(\frac{l}{2\pi}\right)^2$$
$$I_{AB} = \frac{l^3\rho}{8\pi^2} + \frac{\rho l^3}{4\pi^2}$$
$$I_{AB} = \frac{3}{8}\frac{\rho l^3}{\pi^2}$$

523. A wheel having moment of inertia 2kg-m^2 about its axis, rotates at 50 rpm about the same axis. The torque required to stop the wheel in one minute is

(a) $\frac{\pi}{10}$Nm (b) $\frac{\pi}{18}$Nm

(c) $-\frac{\pi}{12}$Nm (d) $\frac{3\pi}{8}$Nm

AP EAMCET (21.04.2019) Shift-II

Ans. (b) : Given,
Moment of inertia (I) = 2 kg-m^2
Initial angular velocity (ω_0) = $2\pi \times 50$ rpm

$$= \frac{2\pi\times 50}{60} = \frac{5\pi}{3}\text{rad/s}$$

Time, t = 1 min = 60 sec
From, $\omega = \omega_0 + \alpha t$

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{0 - 5\pi/3}{60} = -\frac{\pi}{36}\text{rad/s}^2 \quad \text{(Retardation)}$$

The torque that can stop the wheel in one minute-

$$\tau = I\alpha$$
$$\tau = 2 \times \frac{\pi}{36}$$
$$\tau = \frac{\pi}{18}\text{N.m}$$

524. A solid sphere of 100kg and radius 10m moving in a space becomes a circular disc of radius 20m in one hour. Then the rate of change of moment of inertia in the process is

(a) $\frac{40}{9}\text{kgm}^2\text{s}^{-1}$ (b) $\frac{10}{9}\text{kgm}^2\text{s}^{-1}$

(c) $\frac{50}{9}\text{kgm}^2\text{s}^{-1}$ (d) $\frac{25}{9}\text{kgm}^2\text{s}^{-1}$

AP EAMCET (20.04.2019) Shift-1

Ans. (a) : Given,
Mass of solid sphere, M_s = 100 kg
Radius of solid sphere, R_s = 10 m
Radius of circular disc, R_c = 20 m
Time = 1 hour = 60 × 60 sec = 3600 sec
Moment of inertia of the solid sphere,

$$I_s = \frac{2}{5}M_sR_s^2$$
$$I_s = \frac{2}{5}\times 100 \times (10)^2 = 4000\text{ kg-m}^2$$

Moment of inertia of the disc,

$$I_c = \frac{1}{2}M_cR_c^2$$
$$I_c = \frac{1}{2}\times 100 \times (20)^2$$
$$I_c = 20000\text{ kg-m}^2$$

Rate of change of moment of inertia,

$$\frac{\Delta I}{t} = \frac{I_c - I_s}{t}$$
$$\frac{\Delta I}{t} = \frac{20000 - 4000}{3600} = \frac{16000}{3600}$$
$$\frac{\Delta I}{t} = \frac{40}{9}\text{kgm}^2\text{s}^{-1}$$

525. From a circular card board of uniform thickness and mass M, a square disc of maximum possible area is cut. If the moment of inertia of the square with the axis of rotation at the centre and perpendicular to the plane of the disc is $\frac{Ma^2}{6}$, the radius of the circular card board is

@apna_pdf

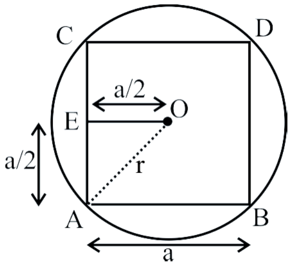
(a) $\sqrt{2}a$ (b) $\frac{a}{\sqrt{2}}$

(c) 2a (d) $\frac{1}{2a}$

(e) $2\sqrt{2}a$

Kerala CEE -2018

Ans. (b) :



Let,

Radius of the circular card = r

And side of square = a

Form the triangle ΔAEO :–

Applying Pythagoras theorem

$$(AO)^2 = (AE)^2 + (OE)^2$$

$$r^2 = \left(\frac{a}{2}\right)^2 + \left(\frac{a}{2}\right)^2$$

$$r^2 = \frac{a^2}{4} + \frac{a^2}{4}$$

$$r^2 = \frac{2a^2}{4}$$

$$r^2 = \frac{a^2}{2}$$

$$r = \frac{a}{\sqrt{2}}$$

526. Which one of the following has maximum inertia?

(a) An atom (b) A molecule

(c) A one-rupee coin (d) A cricket ball

NDA (I) 2018

Ans. (d) : Inertia depends upon quantity of mass.
So, cricket ball has maximum quantity of mass. So, it have maximum moment of inertia.

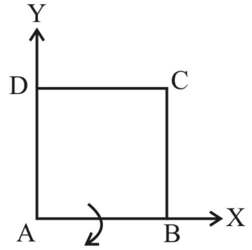
527. A square frame ABCD is formed by four identical rods each of mass 'm' and length '*l*'. This frame is in X-Y plane such that side AB coincides with X-axis and side AD along Y-axis. The moment of inertia of the frame about X-axis is

(a) $\frac{5ml^2}{3}$ (b) $\frac{2ml^2}{3}$

(c) $\frac{4ml^2}{3}$ (d) $\frac{ml^2}{12}$

MHT-CET 2018

Ans. (a) : Given that, mass of each rod = m, length of each rod = *l*



Axis of rotation is passing through X–axis

therefore, $I_{AB} = 0$

Moment of inertia of rod AD & BC about X-axis $= \frac{1}{3}ml^2$

So, $I_{AD} = I_{BC} = \frac{ml^2}{3}$

Rod DC is at distance *l* from axis of rotation

Thus, $I_{DC} = ml^2$

Moment of inertia of the system-

$$I = I_{AB} + I_{BC} + I_{AD} + I_{DC}$$

$$= 0 + \frac{ml^2}{3} + \frac{ml^2}{3} + ml^2$$

$$= \frac{5}{3}ml^2$$

528. Find ratio of radius of gyration of a disc and ring of same radii at their tangential axis in plane.

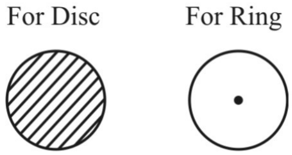
(a) $\sqrt{\frac{5}{6}}$ (b) $\sqrt{\frac{5}{3}}$

(c) 1 (d) $\frac{2}{3}$

JIPMER-2018

AIPMT - 2004, 2008

Ans. (a) :



For disc, $MK_1^2 = \frac{5}{4}MR^2$ ....(i)

For ring, $MK_2^2 = \frac{3}{2}MR^2$ ....(ii)

Taking ratio of equation (i) and (ii), we get

$$\frac{MK_1^2}{MK_2^2} = \frac{\frac{5}{4}MR^2}{\frac{3}{2}MR^2}$$

Hence, $\frac{K_1}{K_2} = \sqrt{\frac{5}{6}}$

@apna_pdf

529. A disc of moment of inertia 2 kg-m^2 revolving with 8 rad/s is placed on another side of moment of inertia 4 kg-m^2 revolving 4 rad/s. What is the angular frequency of composite disc?

(a) 4 rad/s (b) $\frac{3}{16}$ rad/s

(c) $\frac{16}{3}$ rad/s (d) $\frac{16}{5}$ rad/s

JIPMER-2018

Ans. (c) : Given,

Disc-1	Disc-2
$I_1 = 2$ kgm^2	$I_2 = 4$ kgm^2
$\omega_1 = 8$ rad/sec	$\omega_2 = 4$ rad/sec

Applying law of conservation of angular momentum–

$$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$$

$$2 \times 8 + 4 \times 4 = 6 \times \omega$$

$$\omega = \frac{32}{6}$$

Hence, $\omega = \frac{16}{3}$ rad/s

530. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a horizontal frictionless surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. What is the velocity of the centre of mass?

(a) 5 m/s (b) 10 m/s

(c) 20 m/s (d) 30 m/s

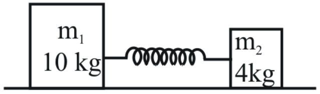
COMEDK 2018

Ans. (b): Given, mass of the blocks,

$m_1 = 10$ kg, $m_2 = 4$ kg

and their velocities,

$v_1 = 14$, $v_2 = 0$



Just after collision,

Velocity of centre of mass,

$$v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

$$= \frac{10\times14 + 4\times0}{10+4} = \frac{140}{14} = 10 \text{ m/s}$$

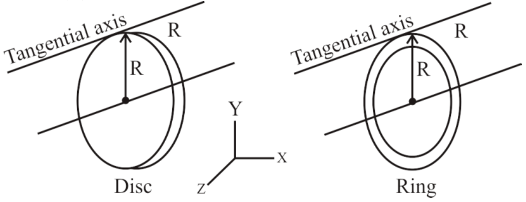
531. The ratio of the radii of gyration of a circular disc and a circular ring of the same radius and same mass about a tangential axis perpendicular to plane of disc or ring is

(a) $\sqrt{3}:2$ (b) 2:3

(c) 1:2 (d) $\sqrt{5}:\sqrt{6}$

COMEDK 2018

Ans. (a) :



$\because I = mk^2$ (k→radius of gyration)

Moment of inertia of a circular disc about tangential axis perpendicular to plane of disc,

$$I_{disc} = \frac{1}{2}MR^2 + MR^2 = \frac{3MR^2}{2}$$

$$MK^2_{disc} = \frac{3MR^2}{2}$$

$$K_{disc} = \sqrt{\frac{3}{2}}R \qquad ....(i)$$

Moment of inertia of a ring for a similar axis,

$$I_{ring} = MR^2 + MR^2 = 2MR^2$$

$$MK^2_{ring} = 2MR^2$$

$$K_{ring} = \sqrt{2}R \qquad ....(ii)$$

From eq. (i) ÷ (ii),

$$\therefore \frac{K_{disc}}{K_{ring}} = \frac{\sqrt{\frac{3}{2}}R}{\sqrt{2}R}$$

$$\frac{K_{disc}}{K_{ring}} = \frac{\sqrt{3}}{2}$$

$$K_{disc} : K_{ring} = \sqrt{3}:2$$

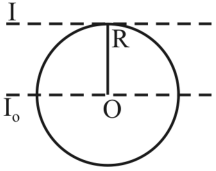
532. The moment of inertia of a disc of mass m and radius R about an axis, which is tangential to the circumference of the disc and parallel to its diameter is

(a) $\frac{3}{2}mR^2$ (b) $\frac{2}{3}mR^2$

(c) $\frac{5}{4}mR^2$ (d) $\frac{4}{5}mR^2$

JIPMER-2018
UP CPMT -2015
Manipal UGET-2013

Ans. (c) : Given, mass of the disc = m, radius = R



Moment of inertia of circular disc $(I_0) = \frac{mR^2}{4}$

$\therefore$ Moment of inertia of disc about a tangent passing through circumference of the disc and parallel to its diameter

$$I = I_0 + mR^2 = \frac{mR^2}{4} + mR^2 = \frac{5}{4}mR^2$$

533. The moment of inertia of a uniform horizontal solid cylinder of mass M about an axis passing through its edge and perpendicular to the axis of the cylinder, when its length is 6 times its radius R, is

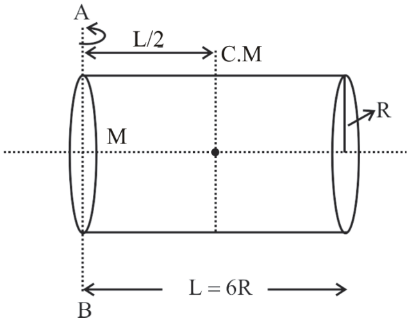
(a) $\frac{49MR^2}{4}$ (b) $\frac{39MR^2}{4}$

@apna_pdf

(c) $\frac{36MR^2}{11}$ (d) $\frac{3MR^2}{2}$

CG PET -2018

Ans. (a) :



At the moment of inertia of a solid cylinder about perpendicular axis passing through its center

$$I_{CM} = \frac{ML^2}{12} + \frac{MR^2}{4}$$

Moment of inertia about AB, Parallel to axis passing through its center and perpendicular to its plane

$$I = I_{CM} + M\left(\frac{L}{2}\right)^2 = \frac{ML^2}{12} + \frac{MR^2}{4} + \frac{ML^2}{4}$$

$$I = \frac{M(6R)^2}{12} + \frac{MR^2}{4} + \frac{M(6R)^2}{4} \qquad (\because L = 6R)$$

$$= \frac{36MR^2}{12} + \frac{MR^2}{4} + \frac{36MR^2}{4}$$

$$I = \frac{147}{12}MR^2 = \frac{49}{4}MR^2$$

$$I = \frac{49}{4}MR^2$$

534. A circular coil of radius 9 cm carrying a current of 2A is free to rotate about an axis in its plane perpendicular to an external magnetic field of $\pi \times 10^{-2}$T. When the coil is tuned slightly and released, it oscillates about its stable equilibrium with a time period of $\frac{1}{3}$ s. If the moment of inertia of the coil about its axis of rotation is 9×10^{-5} kgm^2, the number of turns of the coil is _____.

(a) 10 (b) 20
(c) 30 (d) 40

AP EAMCET-25.04.2017, Shift-I

Ans. (b) : Given,
Radius of coil (r) = 9cm = 0.09m
Current (i) = 2 A
Magnetic Field (B) = $\pi \times 10^{-2}$ T
Time (T) = $\frac{1}{3}$ s
Moment of Inertia (I) = 9×10^{-5} kgm^2
We know,
Magnetic moment (M) = NiA

$$M = Ni\pi r^2 \qquad \ldots(i)$$

and Time period (T) = $2\pi\sqrt{\frac{I}{MB}}$

Replacing the value M from equation (i)in the above equation,

$$T = 2\pi\sqrt{\frac{I}{N \times i \times \pi r^2 \times B}}$$

$$\frac{1}{3} = 2\pi\sqrt{\frac{9 \times 10^{-5}}{N \times 2 \times \pi \times (0.09)^2 \times \pi \times 10^{-2}}}$$

Squaring both side,

$$\frac{1}{9} = \frac{4\pi^2 \times 9 \times 10^{-5} \times 10^4}{N \times 2 \times \pi \times 9 \times 9 \times \pi \times 10^{-2}}$$

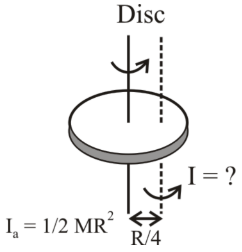
N = 2 × 10
Hence, N = 20 turns

535. A small hole is made in a circular disc of mass 'M' and radius 'R' at a distance of $\frac{R}{4}$ from the centre. The disc is supported on a horizontal peg through this hole. The moment of inertia of the disc about the horizontal peg is

(a) $\frac{9MR^2}{16}$ (b) $\frac{5MR^2}{4}$
(c) $\frac{5MR^2}{16}$ (d) $\frac{MR^2}{9}$

AP EAMCET-25.04.2017, Shift-II

Ans. (a) : Given, mass of circular disc = M
Radius of circular disc = R



We know that,

$$I_a = \frac{1}{2}MR^2 \qquad \text{[for disc]}$$

Apply parallel axis theorem,

$$I = I_a + Mx^2$$

$$I = \frac{1}{2}MR^2 + M\left(\frac{R}{4}\right)^2$$

$$I = \frac{1}{2}MR^2 + \frac{MR^2}{16}$$

$$I = \frac{9}{16}MR^2$$

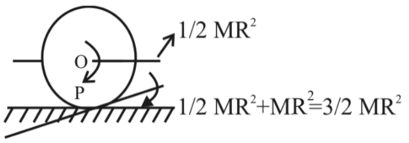
536. A solid cylinder of mass M and radius R rolls on a flat surface. Find its moment of inertia about the line of contact

(a) $\left(\frac{3}{2}\right)MR^2$ (b) MR^2
(c) $2MR^2$ (d) $\left(\frac{2}{3}\right)MR^2$

J&K-CET-2017

@apna_pdf

Ans. (a):



We know,

Moment of inertia of solid cylinder at O $(I_O) = \frac{1}{2}MR^2$

By using parallel axis theorem,

Moment of inertia of solid cylinder at P $(I_P) = I_O + MR^2$

$$I_P = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

Moment of inertia about the line of contact is 3/2 MR^2

537. A body of mass 5 kg acquires an angular acceleration of 10 rad s^{-2} by an applied torque of 2 N m. Find its radius of gyration.

(a) 2.5m
(b) $\sqrt{2.5}$m
(c) $\sqrt{0.2}$m
(d) 0.2 m

J&K-CET-2017

Ans. (d): Given that,

$m = 5$ kg

$\alpha = 10$ rad/sec^2

$\tau = 2$Nm

We know that

$$\tau = I\alpha$$

$$2 = I \times 10$$

$$I = \frac{2}{10}$$

$$I = \frac{2}{10}\text{Kgm}^2$$

$$I = mk^2$$

$$\frac{2}{10} = 5k^2$$

$$\frac{2}{10} = 5k^2 \Rightarrow k^2 = \frac{2}{50} = \frac{1}{25}$$

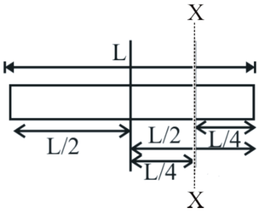
$$k = \frac{1}{5} = 0.2 \text{ m}$$

538. What is the M.I. of a thin rod of length L and M about an axis passing through a point midway between the centre of the edge and perpendicular to its length?

(a) $\frac{7ML^2}{12}$
(b) $\frac{ML^2}{4}$
(c) $\frac{7ML^2}{48}$
(d) $\frac{7ML^2}{44}$

COMEDK 2017

Ans. (c) :



Applying parallel axis theorem

$$I_{xx} = I_{CM} + Mx^2$$

$$I_{xx} = I_{CM} + M\left(\frac{L}{4}\right)^2$$

$$= \frac{ML^2}{12} + \frac{ML^2}{16}$$

$$= \frac{4ML^2 + 3ML^2}{48}$$

$$\therefore \quad I_{xx} = \frac{7ML^2}{48}$$

539. Assertion: Radius of gyration of body is a constant quantity.

Reason: The radius of gyration of a body about an axis of rotation may be defined as the root mean square distance of the particle from the axis of rotation.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-2017

Ans. (d) :

The radius of gyration is depend upon the location of axis of the body.

$$K = \sqrt{\frac{r_1^2 + r_2^2 + r_3^2 + \ldots\ldots\ldots r_n^2}{n}}$$

Thus it depends upon shape and size of the body, its rotation and configuration of the axis of rotation and also on distribution of mass of body with respect to the axis of rotation.

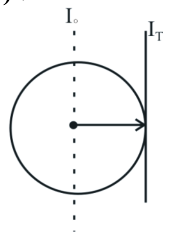
540. The moment of inertia of a sphere of mass M and radius R about an axis passing through its centre is $\frac{2}{5}$MR^2. The radius of gyration of the sphere about a parallel axis to the above and tangent to the sphere is

(a) $\frac{7}{5}$R
(b) $\frac{3}{5}$R
(c) $\left(\sqrt{\frac{7}{5}}\right)$R
(d) $\left(\sqrt{\frac{3}{5}}\right)$R

JCECE-2017

@apna_pdf

Ans. (c) :



Given,
Moment of inertia of a solid sphere about an axis passing through its centre.

$$I_0 = \frac{2}{5}MR^2$$

According to parallel axis theorem,

$$I = I_0 + MR^2$$

$$I = \frac{2}{5}MR^2 + MR^2$$

$$I = \frac{7}{5}MR^2$$

$$MK^2 = \frac{7}{5}MR^2 \qquad \left(\because I = MK^2\right)$$

$$K^2 = \frac{7}{5}R^2$$

$$K = \left(\sqrt{\frac{7}{5}}\right)R$$

541. Two discs of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in the ratio 1 : 3. The moments of inertia of these discs about respective axes passing through their centres and perpendicular to their planes will be in the ratio

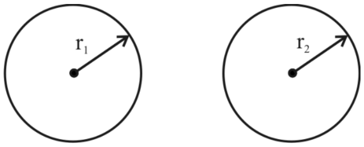
(a) 1 : 3 (b) 3 : 1
(c) 1 : 9 (d) 9 : 1

CG PET- 2017

Ans. (b) : Given that,
Thickness and mass are same for both disc

Ratio of the densities of the materials $\frac{\rho_1}{\rho_2} = \frac{1}{3}$

Let mass = M
Thickness = L



$$\text{Density } (\rho) = \frac{\text{mass(M)}}{\text{Volume(V)}}$$

$$\rho_1 = \frac{M}{\pi r_1^2 L}$$

And $$\rho_2 = \frac{M}{\pi r_2^2 L}$$

According to the question

Now, $$\frac{\rho_1}{\rho_2} = \frac{\frac{M}{\pi r_1^2 L}}{\frac{M}{\pi r_2^2 L}}$$

$$\frac{\rho_1}{\rho_2} = \frac{r_2^2}{r_1^2}$$

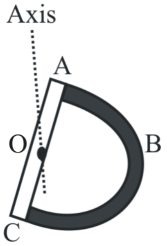
$$\frac{1}{3} = \frac{r_2^2}{r_1^2} \Rightarrow \frac{r_1^2}{r_2^2} = \frac{3}{1}$$

Therefore, $$\frac{I_1}{I_2} = \frac{\frac{1}{2}Mr_1^2}{\frac{1}{2}Mr_2^2} = \frac{r_1^2}{r_2^2} = 3$$

$$\frac{I_1}{I_2} = \frac{3}{1}$$

$$I_1 : I_2 = 3 : 1$$

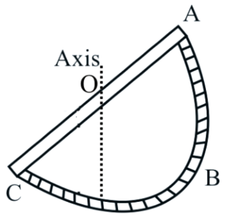
542. Thin semi-circular part ABC has mass m_1 and diameter AOC has mass m_2. Here, axis passes through mid-point of diameter and the axis is perpendicular to plane ABC. Here, AO = OC= R. The moment of inertia of this composite system about the axis is



(a) $\frac{m_1R^2}{2} + \frac{m_2R^2}{3}$ (b) $\frac{m_1R^2}{2} + \frac{m_2R^2}{6}$
(c) $m_1R^2 + \frac{m_2R^2}{3}$ (d) $m_1R^2 + \frac{m_2R^2}{12}$

UPSEE - 2017

Ans. (c) : Given, AO = OC = R
Mass of semicircular part ABC = m_1
Mass of part AOC = m_2



From the diagram,
Total M.O.I. = M.O.I. of semicircular part ABC + M.O.I. of part AOC

$$I = I_{ABC} + I_{AOC}$$

$$= m_1R^2 + m_2\frac{(AC)^2}{12} \qquad [\because AC = OA + OC]$$

@apna_pdf

$$= m_1R^2 + m_2\frac{(2R)^2}{12}$$

$$= m_1R^2 + m_2\frac{4R^2}{12}$$

$$I = m_1R^2 + \frac{m_2R^2}{3}$$

543. Two discs rotating about their respective axis of rotation with angular speed 2 rad.s^{-1} and 5 rad.s^{-1} are brought into contact such that their axes of rotation coincide. Now, the angular speed of the system becomes 4rad.s^{-1}. If the moment of inertia of the second disc is 1× 10^{-3} kg-m^2, then the moment of inertia of the first disc (in kg-m^2) is

(a) 0.25×10^{-3}
(b) 1.5×10^{-3}
(c) 1.25×10^{-3}
(d) 0.75×10^{-3}
(e) 0.5×10^{-3}

Kerala CEE- 2014

Ans. (e) : Given:

Angular speed of the discs are,

$\omega_1 = 2$ rad/sec

$\omega_2 = 5$ rad/sec

Angular speed after coinciding their axes of rotation,

$\omega = 4$ rad/sec

$I_2 = 1 \times 10^{-3}$ kg m^2

$I_1 = ?$

Applying law of conservation of angular momentum,

$$L_f = L_i$$

$$(I_1 + I_2)\omega = I_1\,\omega_1 + I_2\,\omega_2$$

$$(I_1 + 1 \times 10^{-3}) \times 4 = (I_1 \times 2) + (1 \times 10^{-3} \times 5)$$

$$4I_1 + 4 \times 10^{-3} = 2I_1 + 5 \times 10^{-3}$$

$$4I_1 - 2I_1 = 5 \times 10^{-3} - 4 \times 10^{-3}$$

$$2I_1 = 1 \times 10^{-3}$$

$$I_1 = \frac{1}{2} \times 10^{-3}$$

$$= 0.5 \times 10^{-3} \text{ kg-m}^2$$

544. A body of mass 1.5 kg rotating about an axis with angular velocity of 0.3rad.s^{-1} has the angular momentum of 1.8kg-m^{2}s^{-1}. The radius of gyration of the body about an axis is

(a) 2 m
(b) 1.2 m
(c) 0.2 m
(d) 1.6 m
(e) 0.8 m

Kerala CEE- 2013

Ans. (a) : Given:

$m = 1.5$ kg

$\omega = 0.3$ rad/sec

$L = 1.8$ kg m^2 s^{-1}

Then, angular momentum

$$L = I\omega = mk^2\omega$$

$$1.8 = 1.5 \times k^2 \times 0.3$$

$$k^2 = \frac{1.8}{0.45} = 4$$

$$k = 2 \text{ m}$$

545. The radius of gyration of a solid cylinder of mass M and radius R about its own axis is

(a) $\frac{R}{\sqrt{2}}$
(b) $\frac{R}{2}$
(c) $\frac{R}{\sqrt{3}}$
(d) $\frac{R}{3}$
(e) $\frac{R}{4}$

Kerala CEE 2012

Ans. (a) : Since the moment of inertia,

$$I = M\,k^2$$

So, the radius of gyration of a solid cylinder,

$$k = \sqrt{\frac{I}{M}} \quad \text{....(i)}$$

Moment of Inertia of solid cylinder $(I) = \frac{MR^2}{2}$

Put the value of I in equation (i),

$$k = \sqrt{\frac{MR^2}{2M}}$$

$$k = \sqrt{\frac{R^2}{2}} = \frac{R}{\sqrt{2}}$$

546. A flywheel of moment of inertia 3 × 10^{2}kg-m^2 is rotating with uniform angular speed of 4.6 rad.s^{-1}. If a torque of 6.9 × 10^2 Nm retards the wheel, then the time in which the wheel comes to rest is

(a) 1.5 s
(b) 2 s
(c) 0.5 s
(d) 1 s
(e) 2.5 s

Kerala CEE - 2010

Ans. (b) : Given:

Moment of inertia (I) = 3×10^2 kg m^2

Angular speed (ω) = 4.6 rad/sec

Torque (τ) = 6.9×10^2 N m

$\because$ Torque (τ) = $I\alpha$

$$\tau = I \times \frac{\omega}{t}$$

$$6.9 \times 10^2 = 3 \times 10^2 \times \frac{4.6}{t}$$

$$t = \frac{3 \times 10^2 \times 4.6}{6.9 \times 10^2} = 1.826$$

t□ 2 sec

547. Moment of inertia of a ring of mass M and radius R about a tangent to the circle of the ring is

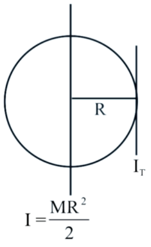
(a) $\frac{5}{2}MR^2$
(b) $\frac{3}{2}MR^2$
(c) $\frac{1}{2}MR^2$
(d) MR^2
(e) $\frac{7}{2}MR^2$

Kerala CEE - 2010

@apna_pdf

Ans. (b) : Moment of inertia of ring,

$$I = \frac{MR^2}{2}$$



And Moment of inertia of a ring about a tangent,

$$I_T = \frac{MR^2}{2} + MR^2$$

$$I_T = \frac{3}{2}MR^2$$

548. From a circular ring of mass M and radius R, an arc corresponding to a 90º sector is removed. The moment of inertia of the remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is k times MR^2. Then the value of k is

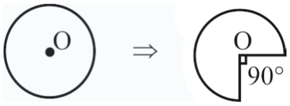
(a) $\frac{3}{4}$ (b) $\frac{7}{8}$

(c) $\frac{1}{4}$ (d) 1

(e) $\frac{1}{8}$

Kerala CEE - 2009

Ans. (a) :



A sector of 90° arc is removed from circular ring then,

Mass of removed sector $= \frac{M}{4}$

Mass of rest portion $= \frac{3M}{4}$

The moment of inertia of circular ring,
$I = MR^2$

The moment of inertia of removed sector $= \frac{1}{4}MR^2$

The moment of inertia of remaining part

$$I' = MR^2 - \frac{1}{4}MR^2$$

$$I' = \frac{3}{4}MR^2$$

Given that moment of inertia of reaming part is
$I' = kMR^2$

$$\frac{3}{4}MR^2 = kMR^2$$

So, the value of $k = \frac{3}{4}$

549. A symmetrical body is rotating about its axis of symmetry, its moment of inertia about the axis of rotation being 1 kgm^2 and its rate of rotation is 2 rev/s. The angular momentum is:

(a) 1.257 kg m^2/s (b) 12.57 kg m^2/s

(c) 13.57 kg m^2/s (d) 20 kg m^2/s

(e) 1.357 kg m^2/s

Kerala CEE 2006

Ans. (b) : Given,
Moment of inertia about the axis of rotation,
$I = 1 \text{ kg m}^2$
Rate of rotation, N = 2 rev/sec
So, angular speed, $\omega = 2\pi N = 2\pi \times 2 = 4\pi \, \text{rad/s}$
Angular momentum $(L) = I\omega = 1(4\pi) = 12.57 \, \text{kg m}^2/\text{s}$

550. The moment of inertia of a thin rod of mass M and length L, about an axis perpendicular to the rod and distance $\frac{L}{4}$ from one end is:

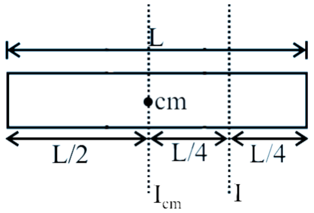
(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{12}$

(c) $\frac{7ML^2}{24}$ (d) $\frac{7ML^2}{12}$

(e) $\frac{7ML^2}{48}$

Kerala CEE 2005

Ans. (e) : The moment of inertia of rod about axis passing through its centre $(I_{cm}) = \frac{ML^2}{12}$



Applying the parallel axis theorem,
$I = I_{cm} + Md^2$

$$I = I_{cm} + M\left(\frac{L}{4}\right)^2 = \frac{ML^2}{12} + \frac{ML^2}{16}$$

$$= \frac{ML^2}{4}\left(\frac{1}{3} + \frac{1}{4}\right) = \frac{ML^2}{4} \times \frac{7}{12}$$

$$\boxed{I = \frac{7ML^2}{48}}$$

551. A diatomic molecule is formed by two atoms which may be treated as mass points m$_1$ and m$_2$ joined by a massless rod of length r. Then, the moment of inertia of the molecule about an axis passing through the centre of mass and perpendicular to rod is

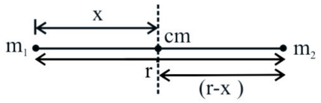
(a) zero (b) $(m_1+m_2)r^2$

(c) $\frac{(m_1+m_2)}{(m_1m_2)}r^2$ (d) $\left(\frac{m_1m_2}{m_1+m_2}\right)r^2$

UPSEE - 2014

@apna_pdf

Ans. (d) :



We know that,Moment of Inertia $= \Sigma m_i r_i^2$

From massless rod,

$$m_1 x = m_2(r-x)$$

$$m_1 x = m_2 r - m_2 x \Rightarrow (m_1+m_2)x = m_2 r$$

$$x = \frac{m_2 r}{m_1+m_2} \qquad \text{....(i)}$$

$$r - x = r - \frac{m_2 r}{m_1+m_2} = \frac{m_1 r + m_2 r - m_2 r}{m_1+m_2}$$

$$r - x = \frac{m_1 r}{m_1+m_2} \text{ .... (ii)}$$

Now, the Moment of Inertia about the centre of mass,

$$(MOI)_{cm} = m_1 x^2 + m_2 (r-x)^2$$

Using eq. (i) and (ii),

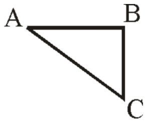
$$(MOI)_{cm} = m_1 \times \left(\frac{m_2 r}{m_1+m_2}\right)^2 + m_2\left(\frac{m_1 r}{m_1+m_2}\right)^2$$

$$= \left(\frac{r}{m_1+m_2}\right)^2 \left[m_1 m_2^2 + m_2 m_1^2\right]$$

$$= \frac{r^2}{(m_1+m_2)^2}\left[m_1 m_2 (m_1+m_2)\right]$$

$$(MOI)_{cm} = \left(\frac{m_1 m_2}{m_1+m_2}\right) r^2$$

552. In a metallic triangular sheet ABC, AB = BC = *l*. If M is mass of sheet, what is the moment of inertia about AC?

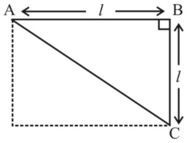


(a) $\frac{Ml^2}{4}$ (b) $\frac{Ml^2}{12}$

(c) $\frac{Ml^2}{6}$ (d) $\frac{Ml^2}{18}$

UPSEE - 2012

Ans. (b) :



Mass of triangular sheet = M

So, Mass of imaginary square = 2M

Moment of Inertia of imaginary square sheet about AC

$$I_{AC} = \frac{(2M)l^2}{12}$$

Moment of Inertia of triangular sheet about AC

$$I_{AC} = \frac{1}{2} \times (2M) \times \frac{l^2}{12} = \frac{Ml^2}{12}$$

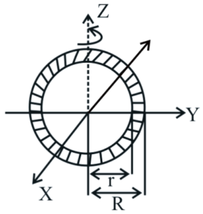
553. The moment of inertia of an annular disc of mass M, outer and inner radii R and r, about its diameter is

(a) $M\left(R^2+r^2\right)/2$ (b) MR^2

(c) Mr^2 (d) $M\left(R^2+r^2\right)/4$

UPSEE - 2011

Ans. (d) :



Moment of Inertia about its center,

$$I_c = M\frac{(R^2+r^2)}{2}$$

Let the moment of inertia about its diameter is I_d

By Applying the perpendicular axis theorem,

$$I_Z = I_X + I_Y$$

$$\text{So, } I_c = I_d + I_d \qquad \{\because I_X = I_Y = I_d\}$$

$$I_c = 2I_d$$

$$I_d = \frac{M(R^2+r^2)}{4}$$

554. A rigid body of mass m rotates about an axis passing through its centre. If the angular velocity of the body is unity, the moment of inertia of the body will be equal to

(a) kinetic energy of the body
(b) twice the kinetic energy of the body
(c) angular momentum of the body
(d) twice the angular momentum of the body

UPSEE - 2011

Ans. (b) : Since, we know that rotational kinetic energy of rigid body,

$$K.E. = \frac{1}{2} I\omega^2$$

Given, $\omega = 1$

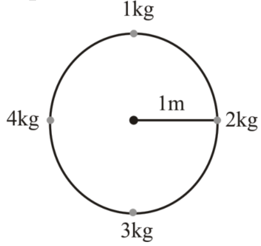
$$\therefore \quad K.E. = \frac{1}{2} I(1)^2$$

$$K.E. = \frac{I}{2}$$

$$I = 2K.E.$$

Thus, moment of inertia of the body equal to twice the kinetic energy of the body.

555. Four balls each of radius 10cm and mass 1kg, 2kg, 3kg and 4kg are attached to the periphery of massless plate of radius 1 m.



@apna_pdf

What is moment of inertia of the system about the centre of plate?

(a) 12.04 kg-m^2 (b) 10.04 kg-m^2
(c) 11.50 kg-m^2 (d) 5.04 kg-m^2

UPSEE - 2010

Ans. (b) : Given,
Mass (m_1) = 1kg, Mass (m_2) = 2kg
Mass (m_3) = 3kg, Mass (m_4) = 4kg
Radius of each ball, $r_1 = r_2 = r_3 = r_4 = 10$ cm
$= 10 \times 10^{-2}$ meter
$= 0.1$ meter
Radius of plate R = 1m

We know that,
Moment of inertia of ball about the centre of plate,

$$I = \frac{2}{5}mr^2$$

$$I_1 = \frac{2}{5}m_1r_1^2 + m_1R^2 \quad ...(1)$$

$$I_2 = \frac{2}{5}m_2r_2^2 + m_2R^2 \quad ...(2)$$

$$I_3 = \frac{2}{5}m_3r_3^2 + m_3R^2 \quad ...(3)$$

$$I_4 = \frac{2}{5}m_4r_4^2 + m_4R^2 \quad ...(4)$$

$$I = I_1 + I_2 + I_3 + I_4$$

$$= \frac{2}{5}[m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + m_4r_4^2] + R^2(m_1 + m_2 + m_3 + m_4)$$

$$= \frac{2}{5}[1\times(0.1)^2 + 2\times(0.1)^2 + 3\times(0.1)^2 + 4\times(0.1)^2] + (1)^2(1+2+3+4)$$

$$= \frac{2}{5}\times(0.01)[1+2+3+4] + (1+2+3+4)$$

$$= \frac{2}{5}\times 0.01\times 10 + 10$$

$$I = 0.04 + 10 = 10.04\,\text{kg - m}^2$$

$$I = 10.04\,\text{kg - m}^2$$

556. If a gymnast, sitting on a rotating stool with his arms outstretched, suddenly lowers his hands.

(a) The angular velocity decreases
(b) His moment of inertia decreases
(c) The angular velocity stays constant
(d) The angular momentum increases

UPSEE - 2010

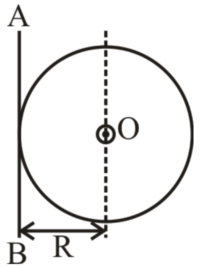
Ans. (b). When the Gymnast, lowers his arms the distribution of mass, changes about the axis of rotation. As Gymnast lowers his arms, mass comes more near to the axis and thus moment of inertia of the rotating system (stool) is reduced.
Hence, when Gymnast lowers his hands, the radius of gyration decreases and M.O.I. also decreases.

557. The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and of a circular ring of the same radius about a tangential axis in the plane of the ring is

(a) $\sqrt{3}:\sqrt{5}$ (b) $\sqrt{12}:\sqrt{3}$
(c) $\sqrt{1}:\sqrt{3}$ (d) $\sqrt{5}:\sqrt{6}$

UPSEE - 2009

Ans. (d) :



We know that,
Moment of inertia of disc, and ring

$$(I_d)_o = \frac{M_dR^2}{4}, \qquad (I_r)_o = \frac{M_rR^2}{2}$$

$$I_{AB} = I_o + MR^2, \qquad I_{AB} = I_o + MR^2$$

$$(I_{AB})_d = \frac{M_dR^2}{4} + M_dR^2, \quad (I_{AB})_r = \frac{M_rR^2}{2} + M_rR^2$$

$$(I_{AB})_d = \frac{5M_dR^2}{4}, \qquad (I_{AB})_r = \frac{3M_rR^2}{2}$$

But $I = Mk^2 \Rightarrow k = \sqrt{\frac{I}{M}}$

Where k = Radius of Gyration

$$\frac{k_d}{k_r} = \sqrt{\frac{(I_{AB})_d}{(I_{AB})_r}\times\frac{M_r}{M_d}} = \sqrt{\frac{\frac{5}{4}M_dR^2}{\frac{3}{2}M_rR^2}\times\frac{M_r}{M_d}}$$

$$\frac{k_d}{k_r} = \sqrt{\frac{5}{6}}$$

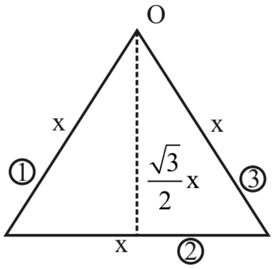
$$k_d : k_r = \sqrt{5}:\sqrt{6}$$

558. Three identical rods, each of length x, are joined to form a rigid equilateral triangle. Its radius of gyration about an axis passing through a corner and perpendicular to the triangle is

(a) $\frac{x}{\sqrt{3}}$ (b) $\frac{x}{2}$
(c) $\sqrt{\frac{3}{2}}x$ (d) $\frac{x}{\sqrt{2}}$

UPSEE - 2008

Ans. (d) : We have to find radius of gyration about point 'O'.



$$I_1 = \frac{Mx^2}{3}, \qquad I_3 = \frac{Mx^2}{3}$$

$$I_1 + I_3 = \frac{Mx^2}{3} + \frac{Mx^2}{3}$$

@apna_pdf

$$I_1 + I_3 = \frac{2Mx^2}{3}$$

$$I_2 = \frac{Mx^2}{12} + M\left(\frac{\sqrt{3}x}{2}\right)^2$$

$$I_2 = \frac{Mx^2}{12} + \frac{3Mx^2}{4} = \frac{Mx^2 + 9Mx^2}{12} = \frac{10Mx^2}{12}$$

$$I_{net} = (I_1 + I_3) + I_2$$

$$I_{net} = \frac{2Mx^2}{3} + \frac{10Mx^2}{12} = \frac{18Mx^2}{12}$$

∴ radius of gyration 'K'

$$I_{net} = (3M)K^2$$

$$\frac{18Mx^2}{12} = 3MK^2 \Rightarrow K^2 = \frac{x^2}{2}$$

Radius of gyration $(K) = \frac{x}{\sqrt{2}}$

559. A thin wire of mass M and length L is bent to form a circular ring. The moment of inertia of this ring about its axis is

(a) $\frac{1}{4\pi^2}ML^2$ (b) $\frac{1}{12}ML^2$

(c) $\frac{1}{3\pi^2}ML^2$ (d) $\frac{1}{\pi^2}ML^2$

UPSEE - 2008

Ans. (a) : Given,

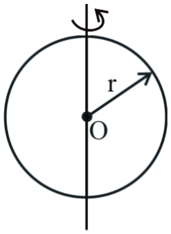
Length of thin wire = L

Mass of thin wire = M

Circumference of ring = Length of thin wire

$$2\pi r = L$$

$$\therefore \quad r = \frac{L}{2\pi}$$



Moment of inertia of a ring about its diameter = Mr^2

∴ Moment of inertia of circular ring, $I = M\left(\frac{L}{2\pi}\right)^2$

$$I = \frac{1}{4\pi^2}ML^2$$

560. Two spheres of equal masses, one of which is a thin spherical shell and the other a solid, have the same moment of inertia about their respective diameters. The ratio of their radii will be

(a) 5:7 (b) 3:5

(c) $\sqrt{3}:\sqrt{5}$ (d) $\sqrt{3}:\sqrt{7}$

UPSEE - 2008

Ans. (c) : Let R_s and R_b be the radii of thin spherical shell and solid respectively.

According to question the masses and moment of inertia of both bodies are equal.

Moment of inertia of thin spherical shell = Moment of inertia of solid sphere-

$$\frac{2}{3}MR_s^2 = \frac{2}{5}MR_b^2$$

$$\frac{R_s^2}{R_b^2} = \frac{3}{5}$$

$$\frac{R_s}{R_b} = \sqrt{\frac{3}{5}}$$

$$R_s : R_b = \sqrt{3} : \sqrt{5}$$

This is the required ratio of their diameters.

561. Two rods each of mass m and length *l* are joined at the centre to form a cross. The moment of inertia of this system about an axis passing through the common centre of the rods and perpendicular to the plane formed by them is:

(a) $ml^2/12$ (b) $ml^2/6$

(c) $ml^2/3$ (d) $ml^2/2$

UPSEE - 2004

Ans. (b) : Given,

Mass of each rod = m, Length of each rod = l

We know that,

Moment of inertia about centre of one rod $= \frac{ml^2}{12}$

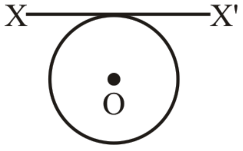
So, Moment of inertia about center of other rod is also $= \frac{ml^2}{12}$

As both moment of inertia are on the common axis,

So, net moment of inertia $= \frac{ml^2}{12} + \frac{ml^2}{12}$

$$I_{net} = \frac{ml^2}{6}$$

562. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown in the figure. The moment of inertia of the loop about the axis XX' is :



(a) $\frac{3\rho L^3}{16\pi^2}$ (b) $\frac{\rho L^3}{16\pi^2}$

(c) $\frac{5\rho L^3}{16\pi^2}$ (d) $\frac{3\rho L^3}{8\pi^2}$

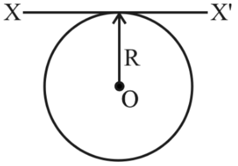
BITSAT-2006

@apna_pdf

Ans. (d) : Moment of inertia of a thin circular coil,

$$I = \frac{MR^2}{2}$$

Now, moment of inertia of a ring about axis XX'



$$I_{XX} = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$$

Mass of the ring, $M = \rho L$

Where, L = length of wire of ring

ρ = linear mass density

$\because \quad L = 2\pi R$

$$R = \frac{L}{2\pi}$$

$$I_{XX} = \frac{3}{2} \times (\rho L) \times \left(\frac{L}{2\pi}\right)^2$$

$$= \frac{3\rho L^3}{8\pi^2}$$

563. What is the moment of inertia of a solid sphere of density ρ and radius R about its diameter?

(a) $\frac{105}{176}R^5\rho$ (b) $\frac{105}{176}R^2\rho$

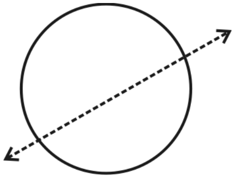
(c) $\frac{176}{105}R^5\rho$ (d) $\frac{176}{105}R^2\rho$

BITSAT-2012, 2009

Ans. (c) : Given that,

Density of solid sphere = ρ

Radius of the sphere = R



We know that,

Mass = density × volume $\left[\rho = \frac{M}{V}\right]$

Mass = V × ρ

$$M = \frac{4}{3}\pi R^3\rho \qquad \left(\because V = \frac{4}{3}\pi R^3\right)$$

And $I = \frac{2}{5}MR^2$ (For solid sphere)

$$I = \frac{2}{5}\left(\frac{4}{3}\pi R^3\rho\right) \times R^2$$

$$= \frac{2}{5} \times \frac{4}{3} \times \frac{22}{7}R^5\rho$$

$$I = \frac{176}{105}\rho R^5$$

564. Two rings of radius R and nR made of same material have the ratio of moment of inertia about an axis passing through centre is 1 : 8. The value of n is

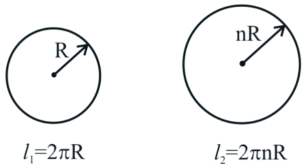
(a) 2 (b) $2\sqrt{2}$

(c) 4 (d) 1/2

BITSAT-2013, 2007

Ans. (a) : Given,

Radius of both rings is R and nR



At the first ring,

$I_1 = MR^2$

$= (\rho l_1)R^2$ (Where α is linear density of the wire)

$= (\rho \times 2\pi R)R^2 \qquad (\because l_1 = 2\pi R)$

$I_1 = 2\pi R^3\rho$

At the second ring

$I_2 = MR^2 = M(nR)^2$

$= \rho l_2 (nR)^2$

$= \rho\,(2\pi nR) \times (nR)^2 \qquad (\because l_2 = 2\pi nR)$

$I_2 = \rho 2\pi n^3R^3$

Ratio between I_1 and I_2

$$\frac{I_1}{I_2} = \frac{2\pi R^3\rho}{\rho 2\pi n^3R^3}$$

$$\frac{1}{8} = \frac{1}{n^3}$$

$n^3 = 2^3$

$n = 2$

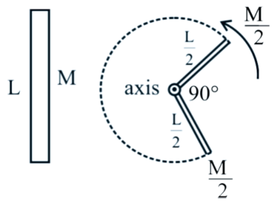
565. A thin rod of length L and mass M is bent at its midpoint into two halves so that the angle between them is 90°. The moment of inertia of the bent rod about an axis passing through the bending point and perpendicular to the plane defined by the two halves of the rod is:

(a) $\frac{ML^2}{24}$ (b) $\frac{ML^2}{12}$

(c) $\frac{ML^2}{6}$ (d) $\frac{\sqrt{2}ML^2}{24}$

BITSAT-2016

Ans. (b) :



@apna_pdf

As the rod is bent into two equal halves, the mass and length, $\frac{M}{2}, \frac{L}{2}$

To the moment of inertia about an axis passing through its edge and perpendicular to the rod.

$$I = \frac{\text{mass} \times (\text{length})^2}{3} = \frac{ML^2}{3}$$

$$I_{net} = 2I = 2 \times \frac{1}{3} \times \frac{M}{2} \times \left(\frac{L}{2}\right)^2 = \frac{ML^2}{12}$$

$$I_{net} = \frac{ML^2}{12}$$

566. A circular disc of radius R and thickness $\frac{R}{6}$ has moment inertia I about an axis passing through its centre perpendicular to its plane. It is melted and recasted into a solid sphere. The moment of inertia of the sphere about its diameter is

(a) I (b) $\frac{2I}{8}$

(c) $\frac{I}{5}$ (d) $\frac{I}{10}$

BITSAT-2016

Ans. (c) Given that,

Radius of disc = R

Thickness of the disc = R/6

Volume of the disc $(V) = \pi R^2 \times \frac{R}{6} = \frac{\pi R^3}{6}$

Moment of inertia of disc $(I) = \frac{MR^2}{2}$,

Sphere is recasted from disc both are consist same volume

So, volume of disc = volume of sphere

$$\frac{\pi R^3}{6} = \frac{4}{3}\pi r^3$$

$$R^3 = 8r^3$$

$$r = \frac{R}{2}$$

To the moment of inertia of sphere about its diameter

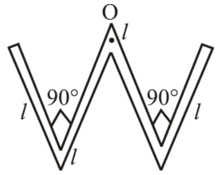
$$(I') = \frac{2}{5}mr^2 = \frac{2}{5}m \times \left(\frac{R}{2}\right)^2 = \frac{1}{10}mR^2$$

Now,

$$\frac{I'}{I} = \frac{\frac{mR^2}{10}}{\frac{mR^2}{2}} = \frac{1}{5}$$

$$I' = \frac{I}{5}$$

567. A thin rod of length 4l and mass 4m is bent at the points as shown in figure. What is the moment of inertia of the rod about the axis passes through point O and perpendicular to the plane of paper?

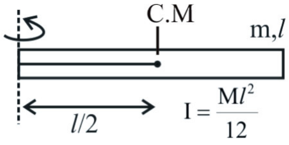


(a) $\frac{ml^2}{3}$ (b) $\frac{10ml^2}{3}$

(c) $\frac{ml^2}{12}$ (d) $\frac{ml^2}{24}$

BITSAT-2015

Ans. (b) :



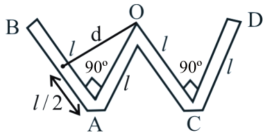
To the moment of inertia of a rod about the axis passing to the end of rod- $I = \frac{ml^2}{12} + m\left(\frac{l}{2}\right)^2$

$$= \frac{ml^2}{12} + \frac{ml^2}{4}$$

$$I = \frac{ml^2}{3}$$

So,

$$I_{OA} = I_{OC} = \frac{ml^2}{3}$$



As all the rod made angle 90°

So, length between O and center of mass of rod AB.

$$d = \sqrt{\left(\frac{l}{2}\right)^2 + l^2}$$

$$d = \sqrt{\frac{5l^2}{4}}$$

Now, moment of Inertia of rod AB,

By using parallel axis theorem,

$$I_{AB} = I_{CD} = \frac{ml^2}{12} + m.d^2$$

$$= \frac{ml^2}{12} + m\left(\sqrt{\frac{5l^2}{4}}\right)^2$$

$$= \frac{ml^2}{12} + \frac{5ml^2}{4} = \frac{4ml^2}{3}$$

Thus moment of Inertia of the system-

$$I = I_{OA} + I_{OC} + I_{AB} + I_{CD}$$

$$= \frac{ml^2}{3} + \frac{ml^2}{3} + \frac{4ml^2}{3} + \frac{4ml^2}{3}$$

$$I = \frac{10}{3}ml^2$$

@apna_pdf

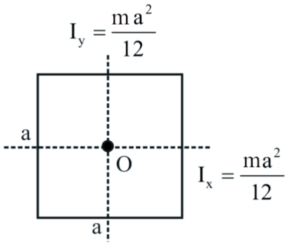
568. Consider a thin uniform square sheet made of a rigid material. If its side is a, mass m and moment of inertia I about one of its diagonals, then

(a) $I > \frac{ma^2}{12}$ (b) $\frac{ma^2}{24} < I < \frac{ma^2}{12}$

(c) $I = \frac{ma^2}{12}$ (d) $I = \frac{ma^2}{24}$

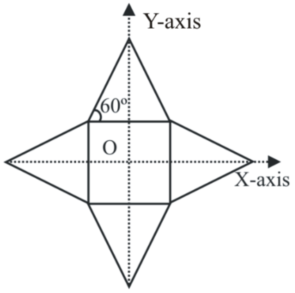
CG PET -2016

Ans. (c) : Given that,
Side of square = a
Mass = m
Moment of inertia = I



$$I_O = I_x + I_y$$
$$= \frac{ma^2}{12} + \frac{ma^2}{12}$$
$$= \frac{ma^2}{6}$$
$$\because \quad I_O = I + I$$
$$I_O = 2I$$
$$I = \frac{I_O}{2}$$
$$I = \frac{ma^2}{6 \times 2}$$
$$I = \frac{ma^2}{12}$$

569. Moment of inertia of a uniform symmetric plate as shown in figure about Y-axis is I. Moment of inertia of this plate about an axis passing through the centre of plate O and perpendicular to the plane of plate is

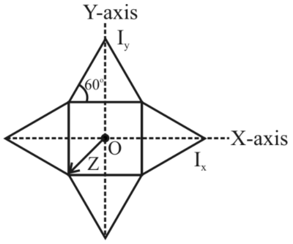


(a) 2I (b) $\frac{I}{2}$

(c) $\frac{I}{4}$ (d) I

CG PET- 2015

Ans. (a) :



Moment of inertia of I_x and I_y,

$I_x = I$ …(i)

$I_y = I$ …(ii)

From perpendicular axis theorem,

$I_z = I_x + I_y$

From equation (i) and (ii)

$I_z = I + I = 2I$

570. I_A and I_B are the moment of inertia of two bodies A and B. They have same geometrical shape. If the first one A is made of gold and the second one B is made of steel, then

(a) $I_A = I_B$ (b) $I_A > I_B$

(c) $I_A < I_B$ (d) None of the above

CG PET- 2013

Ans. (b) : As the geometrical shape of the two bodies is same, so both of them have same volume.

$\because$ mass = volume × density

So, the mass of body A=$V_A \square \rho_A$

and the mass of body B=$V_B \square \rho_B$

The moment of inertia of body A,

$I_A = \text{Mass} \times (\text{distance})^2$

$I_A = (V_A \rho_A)(\text{distance})^2$

and the moment of inertia of body B,

$I_B = \text{Mass} \times (\text{distance})^2$

$I_B = (V_B \rho_B)(\text{distance})^2$

As, the volume and distance of center of mass from axis of both the bodies are same, then

$\therefore \quad I \propto \rho$

Here, geometrical shape is identical so its depends on density. Density of Gold is more than Steel.

So, body having higher density have greater moment of inertia.

As the density of gold is greater than that of steel

so, $I_A > I_B$

571. A point particle of mass 1.0 g is rotating in a circle of diameter 8 cm. Its moment of inertia will be

(a) 2 g-cm^2 (b) 4 g-cm^2

(c) 8 g-cm^2 (d) 16 g-cm^2

CG PET- 2012

Ans. (d) : Given, mass of point particle (M) = 1g, circle of diameter =8cm, radius of the circle $(R) = \frac{8}{2} = 4\text{cm}$

Moment of inertia (I) = MR^2

Putting the value of these we get–

$\because \quad I = 1 \times (4)^2$

$I = 16\text{g cm}^2$

@apna_pdf

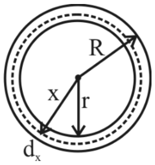
572. On removing the concentric circular part of radius r from a disc of radius R, an annular disc of mass M is obtained. The moment of inertia of this annular disc about an axis normal to its plane and passing through its centre of gravity is

(a) $\frac{1}{2}M(R^2+r^2)$ (b) $\frac{1}{2}M(R^2-r^2)$

(c) $\frac{1}{2}M(R^4+r^4)$ (d) $\frac{1}{2}M(R^4-r^4)$

CG PET- 2011

Ans. (a) :



We know that, $\sigma=\frac{M}{\pi(R^2-r^2)}$ ….. (i)

$dA=2\pi x dx$

Moment of inertia $(I)=\int_r^R \sigma dA\times x^2$

$=\int_r^R \sigma\times 2\pi x.dx\times x^2$

$=2\sigma\pi\int_r^R x^3dx=2\sigma\pi\left[\frac{x^4}{4}\right]_r^R$

$I=\frac{\sigma\pi}{2}(R^4-r^4)$ ……… (ii)

Putting the value of equation (i) in equation (ii), we get

$I=\frac{M}{\pi(R^2-r^2)}\times\frac{\pi}{2}(R^2-r^2)(r^2+R^2)$

$I=\frac{1}{2}M(r^2+R^2)$

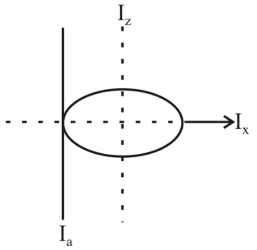
573. If the moment of inertia of a disc about an axis tangential and parallel to its surface be I, then what will be the moment of inertia about the axis tangential but perpendicular to the surface?

(a) $\frac{6}{5}I$ (b) $\frac{3}{4}I$

(c) $\frac{3}{2}I$ (d) $\frac{5}{4}I$

CG PET- 2006

Ans. (a) : Moment of inertia = I



Moment of inertia of disc about tangential axis,

$I=I_x+MR^2$

$I=\frac{1}{4}MR^2+MR^2$

$I=\frac{5}{4}MR^2$

$MR^2=\frac{4}{5}I$

Moment of inertia about an axis that is tangential and perpendicular to the surface of the disc, then by parallel axis theorem, $I_0=I_{CM}+MR^2$

$=\frac{1}{2}MR^2+MR^2=\frac{3}{2}MR^2$

$I_0=\frac{3}{2}\times\frac{4}{5}I \quad \left(\because MR^2=\frac{4}{5}I\right)$

$\frac{I_0}{I}=\frac{6}{5}$

$I_0=\frac{6}{5}I$

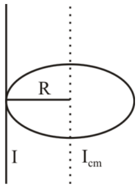
574. The moment of inertia of a uniform circular ring, having a mass M and radius R, about an axis, tangential to the ring and perpendicular to its plane, is

(a) $2MR^2$ (b) $\frac{3}{2}MR^2$

(c) $\frac{1}{2}MR^2$ (d) MR^2

CG PET- 2005

Ans. (a) :



Moment of inertia of the ring about an axis passing through the centre and perpendicular to the plane of ring

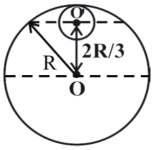
$I=MR^2$

According to parallel axis theorem of the moment of inertia of the ring about tangential axis and perpendicular to its plane is

$I=I_{CM}+MR^2$

$=MR^2+MR^2=2MR^2$

575. A circular disc of radius $\frac{R}{3}$ is cut from a circular disc of radius R and mass 9M as shown. Then, moment of inertia of remaining disc about 'O' perpendicular to the plane of the disc is



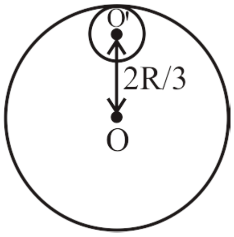
(a) $4MR^2$ (b) $9MR^2$

(c) $\frac{37}{9}MR^2$ (d) $\frac{40}{9}MR^2$

Manipal UGET-2014

@apna_pdf

Ans. (a) : Given, Mass of disc = 9M, circular disc of radius = R/3



Mass per unit area of disc = $\frac{9M}{\pi R^2}$

Mass of removed portion $= \frac{9M}{\pi R^2} \times \pi\left(\frac{R}{3}\right)^2 = M$

Moment of inertia of the removed portion about the axis passing through point O perpendicular to plane of disc

$$I_1 = \frac{1}{2}M \times \left(\frac{R}{3}\right)^2 + M\left(\frac{2R}{3}\right)^2$$

$$= \frac{MR^2}{18} + \frac{4MR^2}{9} = \frac{9MR^2}{18} = \frac{MR^2}{2}$$

Moment of inertia of complete disc about the axis passing through center perpendicular to plane of disc

$$I_2 = \frac{1}{2} \times 9M \times R^2 = \frac{9MR^2}{2}$$

Now,

Moment of inertia of remaining disc (I) = $I_2 - I_1$

$$= \frac{9MR^2}{2} - \frac{MR^2}{2}$$

$$= \frac{8MR^2}{2}$$

$$= 4MR^2$$

576. A solid sphere of mass M, radius R and having moment of inertia about an axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plane remains I. Then, radius of the disc will be

(a) $\frac{2R}{\sqrt{15}}$ (b) $R\sqrt{\frac{2}{15}}$

(c) $\frac{4R}{\sqrt{15}}$ (d) $\frac{R}{4}$

Manipal UGET-2014

Ans. (a) : For solid sphere, moment of inertia about an axis passing through the centre of mass

$$I = \frac{2}{5}MR^2$$

Moment of inertia of circular disc about an axis passing through the center of mass and perpendicular to its plane = $\frac{1}{2}Mr^2$

According to parallel axis theorem-

$$I_1 = \frac{Mr^2}{2} + Mr^2 = \frac{3Mr^2}{2}$$

Where, (r) = radius of the disc

According to question

$$\therefore \quad \frac{2}{5}MR^2 = \frac{3}{2}Mr^2$$

$$r^2 = \frac{4}{15}R^2$$

$$r = \frac{2}{\sqrt{15}}R$$

577. Two spheres of equal masses, one of which is a thin spherical shell and the other is a solid, have the same moment of inertia about their respective diameters. The ratio of their radii will be

(a) 5 : 7 (b) 3 : 5

(c) $\sqrt{3}:\sqrt{5}$ (d) $\sqrt{3}:\sqrt{7}$

Manipal UGET-2013

MHT-CET-2008

Ans. (c) : Let the radii of the thin spherical shell and the solid sphere are R_1 and R_2 respectively, and M be the mass of both the spheres.

Then, the moment of inertia of the spherical shell about its diameter

$$I_1 = \frac{2}{3}MR_1^2 \quad .....(i)$$

Moment of inertia of the solid sphere about its diameter is given by

$$I_2 = \frac{2}{5}MR_2^2 \quad ....(ii)$$

Given that moment of inertia for both the bodies are equal

Then from equation (i) and (ii), we get-

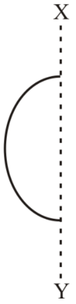
$$\frac{2}{3}MR_1^2 = \frac{2}{5}MR_2^2$$

$$\frac{R_1^2}{R_2^2} = \frac{3}{5}$$

$$\frac{R_1}{R_2} = \sqrt{\frac{3}{5}}$$

$$R_1 : R_2 = \sqrt{3}:\sqrt{5}$$

578. A rod of length L and mass M is bent to form a semicircular ring as shown in figure. The moment of inertia about XY is



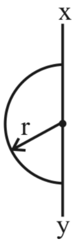
(a) $\frac{1}{4}\frac{ML^2}{\pi^2}$ (b) $\frac{2ML^2}{3\pi^2}$

(c) $\frac{ML^2}{2\pi^2}$ (d) $\frac{2ML^2}{\pi^2}$

Manipal UGET-2010

@apna_pdf

Ans. (c) :



Length (L) = circumference of semi-circle

$$L = \pi r$$

$$r = \frac{L}{\pi}$$

Moment of inertia of half ring about xy,

$$I_{xy} = M \times \frac{r^2}{2}$$

Putting the value of 'r', we get-

$$= \frac{M}{2} \times \left(\frac{L}{\pi}\right)^2$$

$$= \frac{ML^2}{2\pi^2}$$

$$I_{xy} = \frac{ML^2}{2\pi^2}$$

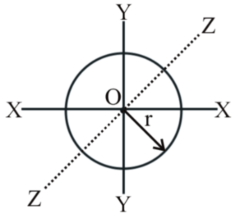
579. The moment of inertia of a circular ring of radius r and mass M about diameter is

(a) $\frac{2}{5}Mr^2$ (b) $\frac{Mr^2}{4}$

(c) $\frac{Mr^2}{2}$ (d) $\frac{Mr^2}{12}$

Manipal UGET-2009
Karnataka CET-2009

Ans. (c) : Given, radius of the circular ring = r ,mass = M



Moment of inertia of ring about an axis passing through its centre and perpendicular to its plane-

$$I_z = Mr^2$$

According to perpendicular axis theorem-

But $I_z = I_x + I_y$ ....(i)

Where, I_x and I_y are along the diameter

$\therefore$ $I_x = I_y$

Now from equation (i), we get-

$2I_x = I_z = Mr^2$

$$I_x = \frac{Mr^2}{2}$$

580. A rod of length L rotates about an axis passing through one of its ends and perpendicular to its plane. If the linear mass density of the rod varies as ρ = (Ar³ + B) kg/m, then the moment of inertia of the rod about the given axis of rotation is

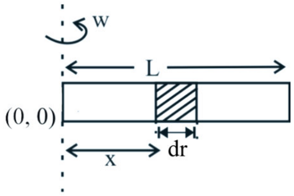
(a) $\frac{L^3}{3}\left[\frac{AL^3}{2}+B\right]$ (b) $\frac{L^2}{3}\left[\frac{AL^2}{2}+B\right]$

(c) $\frac{L^3}{3}\left[\frac{A}{2}+B\right]$ (d) None of these

JCECE-2013

Ans. (a) : Given, rod of length = L

Linear mass density of the rod $(\rho) = (Ar^3 + B)$ kg/m



Let us consider an element of rod and of length dr,

Mass of this element is—

$dm = \rho dr = (Ar^3 + B)dr$

Moment of inertia of this element —

$dI = dm.r^2$

$= (Ar^3 + B)r^2.\ dr$

$= (Ar^5 + Br^2)\ dr$

Integrating both side,

$$\int_0^L dI = \int_0^L Ar^5 dr + \int_0^L Br^2 dr$$

$$I = \left[\frac{Ar^6}{6}\right]_0^L + \left[\frac{Br^3}{3}\right]_0^L$$

$$I = \frac{AL^6}{6} + \frac{BL^3}{3}$$

$$I_{rod} = \frac{L^3}{3}\left(\frac{AL^3}{2} + B\right)$$

581. Inertia is that property of a body by virtue of which the body is

(a) unable to change by itself the state of uniform motion

(b) unable to change by itself the state of rest or of uniform linear motion

(c) unable to change by itself the state of rest

(d) unable to change by itself the direction of motion

JCECE-2012

Ans. (b) : It is an inherent property of all the bodies by virtue of which they cannot change their state of rest or uniform motion along a straight line by their own is called inertia. This is also the Newton's 1st Law.

Inertia is the property of a body by virtue of which the body is unable to change by itself the state of rest only, because the bodies do not change their state unless acted upon by an unbalanced external force.

582. If the external torque acting on a system is zero (i.e. τ = 0), then

(a) J = 0 (b) F = 0

(c) ω = 0 (d) α =0

JCECE-2012

@apna_pdf

Ans. (d) : Given the torque acting upon a system is zero, then angular momentum is constant and hence conserved.

By the relation

$$\tau = I\alpha$$

If $\tau = 0$, then $\alpha = 0$ because moment of inertia of any body cannot be zero.

583. If all of a sudden the radius of the earth decreases, then which one of the following statements will be true?

(a) The angular momentum of the earth will become greater than that of the sun.

(b) The periodic time of the earth will increase.

(c) The energy and angular momentum will remain constant.

(d) The angular velocity of the earth will increase

JCECE-2012

Ans. (d) :

We know, $I = MR^2$

$\Rightarrow$ So, $I \propto R^2$

Radius of earth decrease so moment of inertia decrease,

$\because L = I\,\omega$

Where, (L = angular momentum is constant)

$$\omega = \frac{L}{I}$$

$$\omega \propto \frac{1}{I}$$

Then moment of inertia decrease so angular velocity of the earth will increase.

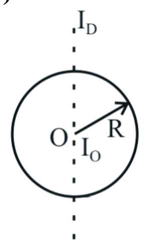
584. Moment of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be

(a) 5 I (b) 3 I

(c) 6 I (d) 4 I

JCECE-2011

Ans. (c) :



Given,

Moment of inertia of uniform circular disc about its diameter

$$I_D = I = \frac{MR^2}{4}$$

From perpendicular axis theorem,

Moment of inertia of disc about its axis,

$$I_x = I_y = I$$

$$I_0 = I + I = 2I$$

$$I_0 = I + I = 2I = 2\times\frac{MR^2}{4}$$

$$I_0 = \frac{MR^2}{2}$$

From theorem of parallel axis,

$$I_C = 2I + MR^2$$

$$= 2I + 4I \qquad \begin{bmatrix} \because 2I = \frac{1}{2}MR^2 \\ \therefore MR^2 = 4I \end{bmatrix}$$

$$I_C = 6I$$

585. Two identical rods of length L, mass M are riveted at right angles at their mid points Moment of inertia of the system about the perpendicular axis passing through the centre is

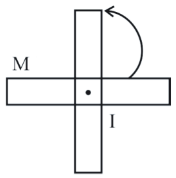
(a) ML^2 (b) $\frac{ML^2}{12}$

(c) $\frac{ML^2}{4}$ (d) $\frac{ML^2}{6}$

COMEDK 2011

Ans. (d) : Moment of inertia of the rod about its centre,

$$I = \frac{ML^2}{12}$$



Moment of inertia of the rod about an axes which is the perpendicular to the rod and passing through the centre,

$$I_z = I_x + I_y = I + I = 2I = 2\times\frac{ML^2}{12}$$

$$\boxed{I_z = \frac{ML^2}{6}}$$

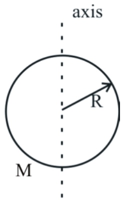
586. The ratio of radii of gyration of a circular ring and a circular disc, of the same mass and radius about an axis passing through their centres and perpendicular to their planes are

(a) $1:\sqrt{2}$ (b) $3:2$

(c) 2:1 (d) $\sqrt{2}:1$

COMEDK 2013

Ans. (d) :



$$I_{ring} = MR^2 = Mk_{ring}^2$$

$K_{ring} \rightarrow$ radius of gyration

$$MR^2 = MK_{ring}^2$$

@apna_pdf

$K_{ring} = R$ ....(i)

$$I_{disc} = \frac{MR^2}{2} = MK_{disc}^2$$

$$MK_{disc}^2 = \frac{MR^2}{2}$$

$$K_{disc} = \frac{R}{\sqrt{2}} \quad ....(ii)$$

Form eq.(i) ÷ (ii),

$$\because \frac{K_{ring}}{K_{disc}} = \frac{R}{R/\sqrt{2}} = \frac{\sqrt{2}}{1}$$

$K_{ring} : K_{disc} = \sqrt{2} : 1$

587. Three point masses, each of mass m are placed at the corners of an equilateral triangle of side *l*. Moment of inertia of this system about an axis along one side of triangle is

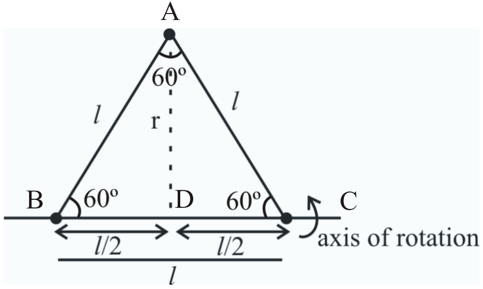
(a) $3ml^2$ (b) $\frac{3}{2}ml^2$

(c) ml^2 (d) $\frac{3}{4}ml^2$

COMEDK 2016

Ans. (d) : We know that,

Moment of inertia (I) = mr^2 ....(i)



From ΔABD,

$$l^2 = r^2 + \left(l/2\right)^2$$

$$l^2 = r^2 + l^2/4$$

$$r^2 = l^2 - l^2/4 = \frac{3}{4}l^2 \Rightarrow \boxed{r^2 = \frac{3}{4}l^2}$$

$$I = mr^2 = m \times \frac{3}{4}l^2 = \frac{3}{4}ml^2$$

$$\boxed{I = \frac{3}{4}ml^2}$$

588. **Assertion:** A judo fighter in order to throw his opponent on to the mat tries to initially bend his opponent and then rotate him around his hip.

Reason: As the mass of the opponent is brought closer to the fighter's hip, the force required to throw the opponent is reduced.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is incorrect but the Reason is correct

AIIMS-2006

Ans. (a) : If both assertion and reason are true and reason is the correct explanation of assertion.

At the judo fighter in order to throw his opponent on the mat tries to initially bend his opponent and then rotate him around his hip because doing this the weight of opponent is made to pass through the hip of judo fighter to make its torque zero.

Torque of the opponent by a judo fighter $\tau = \bar{r} \times \bar{F}$

$= rF \sin\theta\hat{n}$

589. **Assertion:** Moment of inertia depends on the axis of rotation and the nature of distribution of the mass of the body.

Reason: Moment of inertia is the rotational inertia of the body.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-1997

Ans. (b) :

We know the equation

$I = m_1r_1^2 + m_2r_2^2 + m_3r_3^3 + ... + m_nr_n^2$ .....(i)

From equation (i)

We can verified that moment of Inertia (I) depends upon distribution of the mass and position of the axis

So, Assertion is correct.

We know that,

The angular momentum L= Iω

and Torque τ = Iα

If we compare these equations with equations like linear momentum = mv, and force = ma,

We conclude that I represent mass in angular motion. As mass represents inertia in linear motion, and I represents inertia in angular motion.

590. Consider a thin uniform square sheet made of a rigid material. If its side is 'a' mass m and moment of inertia I about one of its diagonals, then

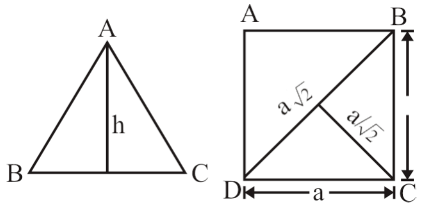
(a) $I > \frac{ma^2}{12}$ (b) $\frac{ma^2}{24} < I < \frac{ma^2}{12}$

(c) $I = \frac{ma^2}{24}$ (d) $I = \frac{ma^2}{12}$

AIIMS-2016

@apna_pdf

Ans. (d) :



We know that,
Moment of Inertia of a Triangle about base

$$I_{BC} = \frac{1}{6}Mh^2$$

Similarly, Square can be break into 2 similar triangle.

Therefore, Moment of Inertia of square about diagonal $= 2 \times I_{BD}$

$$= 2\times\left[\frac{1}{6}\left(\frac{M}{2}\right)\times\left(\frac{a}{\sqrt{2}}\right)^2\right]$$

$$= 2\times\left[\frac{1}{6}\left(\frac{M}{2}\right)\times\frac{a^2}{2}\right]$$

$$I_{Square,} = \frac{Ma^2}{12}$$

For the uniform square plate due to symmetry, moment of inertia about all the axis passing through the centre.

$$I_x = I_y = I_z = I = \frac{ma^2}{12}$$

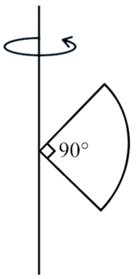
591. One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is

(a) $\frac{1}{2}mR^2$ (b) $\frac{1}{4}mR^2$

(c) $\frac{1}{8}mR^2$ (d) $\sqrt{2}mR^2$

AIIMS-2013

Ans. (a) :



Given,
Radius $= R$
Single quarter sector has the mass = m
And for the completes disc has mass = 4m
We know that,
The moment of inertia of the disc rotating about the line perpendicular to plane and passing through centre

$$= \left[\frac{MR^2}{2}\right]$$

Here moment of inertia of the complete disc = 4m $(R^2/2) = 2mR^2$
Therefore moment of inertia for quarter of disc,
Moment of inertia = $(1/4)(2mR^2)$,

Moment of inertia $= \left[\frac{1}{2}mR^2\right]$.

592. A wire of mass m and length *l* is bent in the form of a circular ring, the moment of inertia of the ring about its axis is

(a) $\left(\frac{1}{8\pi^2}\right)ml^2$ (b) $\left(\frac{1}{2\pi^2}\right)ml^2$

(c) $\left(\frac{1}{4\pi^2}\right)ml^2$ (d) ml^2

AIIMS-2010

Ans. (c) :

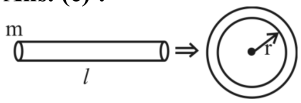


Figure shows, a thin wire of length *l* is bent to form a circular ring.
Then,
Length of the wire = circumference of ring

$$2\pi r = l$$

$$r = \frac{l}{2\pi}$$

Where, r = radius of ring
m = mass of wire
& *l* = length of wire
Therefore, the moment of inertia of the ring about its axis,
$I = mr^2$
By putting the value of r,

$$I = m\left(\frac{l}{2\pi}\right)^2$$

$$\therefore \quad I = \frac{ml^2}{4\pi^2}$$

$$I = \left(\frac{1}{4\pi^2}\right)ml^2$$

593. The angular speed of a body changes from ω_1 to ω_2 without applying a torque but due to changes in moment of inertia. The ratio of radii of gyration in two cases is

(a) $\omega_2 : \omega_1$ (b) $\sqrt{\omega_2} : \sqrt{\omega_1}$

(c) $\sqrt{\omega_2^2} : \sqrt{\omega_1^2}$ (d) $\sqrt{\omega_2^3} : \sqrt{\omega_1^3}$

AIIMS-2009

Ans. (b) : Net external torque (τ_{ext}) is zero on the body therefore its angular momentum will remain conserved.

So, $I_1\,\omega_1 = I_2\,\omega_2$ ….. (i)

We know moment of inertia $I = mK^2$
Where K is radius of gyration

$$\therefore\ mK_1^2\omega_1 = mK_2^2\omega_2$$

$$\frac{K_1}{K_2} = \sqrt{\frac{\omega_2}{\omega_1}}$$

$$\boxed{K_1 : K_2 = \sqrt{\omega_2} : \sqrt{\omega_1}}$$

@apna_pdf

594. Two metallic disc A and B of density d_1 and d_2 respectively, possess same mass and thickness. If I_1 and I_2 are the moment of inertia of A and B respectively, then $I_1 =$

(a) I_2 (b) $\frac{d_2^2}{d_1^2}I_2$

(c) $\frac{d_1}{d_2}I_2$ (d) $\frac{d_2}{d_1}I_2$

J&K-CET-2016

Ans. (d):

	Disc A	Disc B
Density	d_1	d_2
Mass	M	M
Thickness	t	t
M.O.I	I_1	I_2

According to question

$$\frac{I_1}{I_2} = \frac{M_A R_A^2}{M_B R_B^2} = \frac{R_A^2}{R_B^2} \qquad (\because M_A = M_B = M)$$

$$\frac{I_1}{I_2} = \left(\frac{R_A}{R_B}\right)^2 \qquad \left[\begin{array}{l} \because \text{Density} = \frac{\text{Mass}}{\text{Volume}} \\ \frac{d_1}{d_2} = \frac{M.\pi R_B^2 t}{M.\pi R_A^2 t} = \left(\frac{R_B}{R_A}\right)^2 \\ \left(\frac{R_A}{R_B}\right)^2 = \frac{d_2}{d_1} \end{array}\right]$$

$$\frac{I_1}{I_2} = \frac{d_2}{d_1}$$

$$I_1 = \frac{d_2}{d_1}I_2$$

595. Four small objects each of mass m are fixed at the corners of a rectangular wire-frame of negligible mass and of sides and b (*a* > b). If the wire frame is now rotated about an axis passing along the side of length b, then the moment of inertia of the system for this axis of rotation is

(a) $2\ ma^2$ (b) $4ma^2$

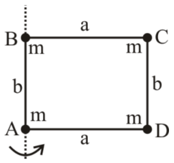
(c) $2m\ (a^2 + b^2)$ (d) $2\ m(a^2 - b^2)$

WB JEE 2013

Ans. (a): According to question

Side (a > b)

Then,



I_{net} = M.O.I of mass at A about AB + M.O.I of mass at B About AB + M.O.I of mass at C about AB + M.O.I of mass at D about AB

$I_{net} = I_A+I_B+I_C+I_D$

$I_{net} = 0+0 + ma^2+ ma^2$

$I_{net} = 2ma^2$

596. The moment of inertia of a solid cylinder of mass M, length 2R and radius R about an axis passing through the centre of mass and perpendicular to the axis of the cylinder is I_1 and about an axis passing through one end of the cylinder and perpendicular of the axis of cylinder is I_2 then

(a) $I_2 < I_1$ (b) $I_2 - I_1 = MR^2$

(c) $\frac{I_2}{I_1} = \frac{19}{12}$ (d) $\frac{I_2}{I_1} = \frac{7}{6}$

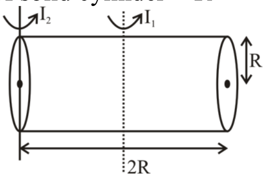
TS EAMCET (Engg.)-2015

Ans. (b): According to question,

Mass of solid cylinder = M

Length of solid cylinder = 2R

Radius of solid cylinder = R



$$I_1 = \frac{1}{4}MR^2 + \frac{1}{12}M(2R)^2$$

$$= \frac{1}{4}MR^2 + \frac{1}{3}MR^2 = \frac{7}{12}MR^2$$

$$I_2 = \frac{1}{4}MR^2 + \frac{1}{3}M(2R)^2$$

$$= \frac{1}{4}MR^2 + \frac{4}{3}MR^2 = \frac{19}{12}MR^2$$

$$\text{So, } I_2 - I_1 = \frac{19}{12}MR^2 - \frac{7}{12}MR^2 = MR^2$$

$I_2 - I_1 = MR^2$

597. Two rigid bodies A and B rotate with rotational kinetic energies E_A and E_B respectively. The moments of inertia of A and B about the axis of rotation are I_A and I_B respectively.

If $I_A = \frac{I_B}{4}$ and $E_A = 100\ E_B$, the ratio of angular momentum (L_A) of A to the angular momentum (L_B) of B is

(a) 25 (b) 5/4

(c) 5 (d) 1/4

JIPMER-2013

Ans. (c) : Given,

$$I_A = \frac{I_B}{4} \quad , \quad E_A = 100\,E_B$$

We know that,

Rotational Kinetic Energy,

$$E = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{(I\omega)^2}{I} \qquad (\because L = I\omega)$$

$$E = \frac{L^2}{2I}$$

Therefore,

$L^2 = 2EI$

$L_A^2 = 2\ E_A I_A$ .....(i)

@apna_pdf

Similarly,

$$L_B^2 = 2E_B I_B \qquad \text{......(ii)}$$

From equation (i) and (ii)

$$\frac{L_A}{L_B} = \sqrt{\frac{2E_A I_A}{2E_B I_B}}$$

$$= \sqrt{\frac{2\times 100E_B \times I_A}{2\times E_B \times 4I_A}} = \sqrt{\frac{100}{4}}$$

$$\frac{L_A}{L_B} = 5$$

598. The radius of gyration of a body about an axis at a distance 6 cm from its centre of mass is 10 cm. Then, its radius of gyration about a parallel axis through its centre of mass will be

(a) 80 cm (b) 8 cm
(c) 0.8 cm (d) 80 m

JIPMER-2011

Ans. (b) : Given,
Radius of gyration (k) = 10 cm
Distance of given axis from center of mass (r) = 6 cm
According to parallel axis theorem,

$$I = I_{c.m} + Mr^2$$

$$Mk^2 = Mh^2 + Mr^2 \qquad (\because I = Mk^2)$$

$$(10)^2 = h^2 + (6)^2$$

$$h = \sqrt{100-36}$$

$$h = \sqrt{64}$$

$$h = 8 \text{ cm}$$

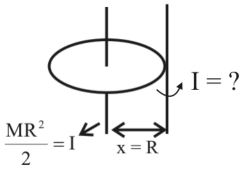
Radius of gyration is 8 cm, about a parallel axis.

599. The moment of inertia of a uniform circular disc of radius R and mass M about an axis passing from the edge of the disc and normal to the disc is

(a) $\frac{1}{2}MR^2$ (b) MR^2
(c) $\frac{7}{2}MR^2$ (d) $\frac{3}{2}MR^2$

AIPMT-2006

Ans. (d) :



Apply parallel axis theorem, the moment of inertia about on axis passing from the edge of that disc.

$$I = I_c + Mx^2$$

$$I = \frac{MR^2}{2} + MR^2 \qquad (\because x = R)$$

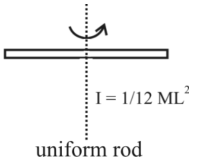
$$I = \frac{3}{2}MR^2$$

600. The radius of gyration of a uniform rod of length L about an axis passing through its centre of mass is

(a) $\frac{L}{\sqrt{12}}$ (b) $\frac{L^2}{12}$
(c) $\frac{L}{\sqrt{13}}$ (d) $\frac{L}{12}$

Assam CEE-2014

Ans. (a) : Moment of inertia of rod $(I) = \frac{ML^2}{12}$ ....(i)



Then, we know that,

$$I = MK^2 \qquad \text{....(ii)}$$

Where K is radius of gyration
From equation (i) and (ii), we get

$$MK^2 = \frac{1}{12}ML^2$$

$$K = \frac{L}{\sqrt{12}}$$

601. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius 4R is made from an iron plate of thickness t/4. The ratio of moments of inertia, I_Y/I_X, is

(a) 32 (b) 16
(c) 1 (d) 64

Assam CEE-2014

Ans. (d) : Given, for disc x, radius = R and thickness = t
For disc y, radius = 4R and thickness = t/4
Mass = volume × density

$$M = \text{Volume} \times \rho = \pi R^2.t.\rho$$

$$M = \pi R^2 t\rho$$

For a disc, moment of inertia $I = \frac{MR^2}{2}$

$$\text{For disc } I_X = \frac{(\pi R^2 t)R^2\rho}{2}$$

$$= \frac{\pi R^4 t\rho}{2} \qquad \text{....(i)}$$

$$\text{For disc Y, } I_Y = \frac{\pi(4R)^2 t/4(4R)^2\rho}{2} = \frac{\pi 4R^2 t(16R^2)\rho}{2}$$

$$I_Y = \frac{\pi 64R^4 t\rho}{2} \qquad \text{....(ii)}$$

Divide equation (ii) by (i)

$$\frac{I_Y}{I_X} = \frac{64\pi R^4 t\rho/2}{\pi R^4 t\rho/2}$$

$$\frac{I_Y}{I_X} = \frac{64}{1} = 64$$

@apna_pdf

602. A wheel of radius 0.4 m can rotate freely about its axis as shown in the figure. A string is wrapped over its rim and a mass of 4 kg is hung. An angular acceleration of 8 rad-s^{-2} is produced in it due to the torque. Then, moment of inertia of the wheel is (g = 10 ms^{-2})

(a) 2 kg-m^2 (b) 1 kg-m^2

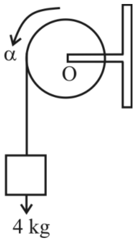
(c) 4 kg-m^2 (d) 8 kg-m^2

AP EAMCET -2009

Ans. (a) : Given that, radius of wheel = 0.4 m

Mass = 4 kg

Angular acceleration = 8 rads^{-2}



We know,

$\tau = I\alpha$ ……(i)

And $\tau = F \times R$ ……(ii)

Equating equation (i) and (ii), we get

$F\times R = I\alpha$ $(\because F = mg)$

$mg \times R = I\alpha$

or $I = \dfrac{4\times10\times0.4}{8}$

$I = 2\ \text{kgm}^2$

603. The moment of inertia of a disc, of mass M and radius R, about an axis which is a tangent and parallel to its diameter is

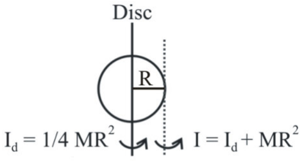
(a) $\frac{1}{2}MR^2$ (b) $\frac{3}{4}MR^2$

(c) $\frac{1}{4}MR^2$ (d) $\frac{5}{4}MR^2$

AP EAMCET -2010

Ans. (d) : Given, mass of disc = M

Radius of disc = R



From parallel axis theorem–

$I_{net} = I_d + MR^2$

$I_{net} = \dfrac{1}{4}MR^2 + MR^2$

$I_{net} = \dfrac{5}{4}MR^2$

604. Moment of inertia of a body about an axis is 4 kg-m^2. The body is initially at rest and a torque of 8 N-m starts acting on it along the same axis. Work done by the torque in 20 s, in joules, is

(a) 40 (b) 640

(c) 2560 (d) 3200

AP EAMCET -2013

Ans. (d) : Given that,

Moment of Inertia (I) = 4 kg-m^2

Torque (τ) = 8 N-m

Time (t) = 20 sec

We know,

$\tau = I\alpha$

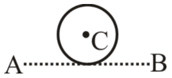
$\alpha = \dfrac{\tau}{I} = \dfrac{8}{4} = 2\ \text{rad/s}^2$ $[\therefore \tau = I\alpha]$

and $\theta = \dfrac{1}{2}\alpha t^2$

$\theta = \dfrac{1}{2}\times2\times20\times20 = 400$

Hence, W = τθ = 8 × 400 = 3200 J

605. A thin wire of length *l* having density ρ is bent into a circular loop with C as its centre, as shown in figure. The moment of inertia of the loop about the line AB is



(a) $\dfrac{5\rho l^3}{16\pi^2}$ (b) $\dfrac{\rho l^3}{16\pi^2}$

(c) $\dfrac{\rho l^3}{8\pi^2}$ (d) $\dfrac{3\rho l^3}{8\pi^2}$

AP EAMCET -2014

AMU-2004

Ans. (d) : Given, length of wire = *l*

Density of wire = ρ

Moment of inertia of loop (I_{AB}) = ?

We know,

$M = \rho l$ ….(i)[∵wire is too thin so A = 1]

Let R be the radius of the ring then,

$l = 2\pi R$ ….(ii)

$R = \dfrac{l}{2\pi}$

Moment of inertia about AB –

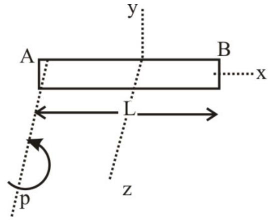
$I_{AB} = \dfrac{1}{2}MR^2 + MR^2$

$I_{AB} = \dfrac{3}{2}MR^2$

Putting the value of M, R from equation (i) and (ii) respectively, we get

$I_{AB} = \dfrac{3}{2}(\rho l)(l^2/4\pi^2) = \dfrac{3\rho l^3}{8\pi^2}$

606. A rod of length L and mass M is rotating about an axis P perpendicular to the rod and parallel to z-axis, passing through one end A of the rod. The moment of inertia for rotation about this axis P is



@apna_pdf

(a) $\frac{1}{12}ML^2$ (b) $\frac{1}{4}ML^2$

(c) $\frac{1}{3}ML^2$ (d) $\frac{5}{12}ML^2$

AMU-2010

Ans. (c): Given,
Mass of rod = M
Length of rod = L
Moment of inertia about one end using parallel axis theorem,

$$I = I_{cm} + Md^2$$

Where,

$I_{cm} = \frac{ML^2}{12}$ (Moment of inertia about center of mass)

$$d = \frac{L}{2}$$

So,

$$I = \frac{ML^2}{12} + M \times \left(\frac{L}{2}\right)^2$$

$$= \frac{ML^2}{12} + \frac{ML^2}{4}$$

$$= ML^2\left[\frac{1}{12} + \frac{1}{4}\right]$$

$$= \frac{4}{12}ML^2$$

$$I = \frac{1}{3}ML^2$$

607. Two rings have their moments of inertia in the ratio 2: 1 and their diameters are in the ratio 2: 1. The ratio of their masses would be in the ratio

(a) 2 : 1 (b) 1 : 2

(c) 1 : 1 (d) 4 : 1

AMU-2004

Ans. (b) : Given,
Ratio between moment of inertia,

$$\frac{I_1}{I_2} = \frac{2}{1}$$

Ratio between diameter,

$$\frac{d_1}{d_2} = \frac{2}{1}$$

$$\frac{R_1}{R_2} = \frac{2}{1}$$

Find $\frac{M_1}{M_2} = ?$

We know,

$$I = MR^2$$

$$= M \times \left(\frac{d}{2}\right)^2 \Rightarrow \frac{Md^2}{4}$$

$$\because \quad I_1 = \frac{M_1(d_1)^2}{4}, \quad I_2 = \frac{M_2(d_2)^2}{4}$$

According to the question,

$$\frac{I_1}{I_2} = \frac{M_1(d_1)^2}{M_2(d_2)^2}$$

$$\frac{2}{1} = \frac{M_1}{M_2}\left(\frac{2}{1}\right)^2$$

$$\frac{M_1}{M_2} = \frac{1}{2}$$

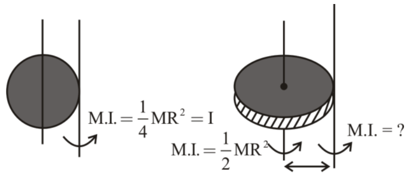
608. Moment of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be

(a) 5I (b) 3I

(c) 6I (d) 4I

AIPMT- 1990, 2006

Ans. (c) :



Given,
Moment of inertia of disc about a diameter

$$I = \frac{1}{4}MR^2$$

$$\therefore \quad MR^2 = 4I$$

Now, apply parallel axis theorem,

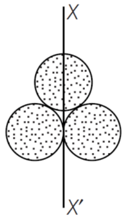
$$M.I. = \frac{1}{2}MR^2 + MR^2$$

$$M.I. = \frac{3}{2}MR^2$$

$$M.I. = \frac{3}{2} \times 4I$$

$$M.I. = 6I$$

609. Three identical spherical shells, each of mass m and radius r are placed as shown in figure. Consider an axis XX′, which is touching to two shells and passing through diameter of third shell.



Moment of inertia of the system consisting of these three spherical shells about XX′ axis is

(a) $\frac{11}{5}mr^2$ (b) $3\ mr^2$

(c) $\frac{16}{5}mr^2$ (d) $4\ mr^2$

AIPMT- 2015

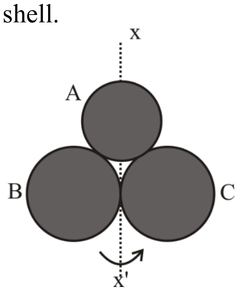
@apna_pdf

Ans. (d) : Given,

Mass = m

Radius = r

All are spherical shell.



Moment of inertia of the system about XX' axis,

$$\text{M.I.} = (\text{M.I})_A + (\text{M.I})_B + (\text{M.I})_C$$

$$\text{M.I.} = \frac{2}{3}\text{mr}^2 + \left(\frac{2}{3}\text{mr}^2 + \text{mr}^2\right) + \left(\frac{2}{3}\text{mr}^2 + \text{mr}^2\right)$$

$$\text{M.I.} = 3 \times \frac{2}{3}\text{mr}^2 + 2\text{mr}^2$$

$$\text{M.I.} = 4\text{mr}^2$$

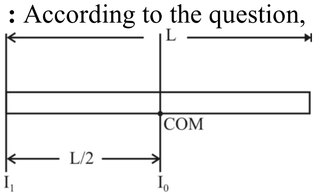
610. The moment of inertia of a thin uniform rod of mass M and length L about an axis passing through its mid-point and perpendicular to its length is I_0. Its moment of inertia about an axis passing through one of its ends and perpendicular to its length is

(a) $I_0 + ML^2/4$ (b) $I_0 + 2ML^2$

(c) $I_0 + ML^2$ (d) $I_0 + ML^2/2$

AIPMT- 2011

Ans. (a) : According to the question,



By using parallel axis theorem,

$$I_1 = I_{COM} + Mr^2$$

$$I_1 = I_0 + M(L/2)^2$$

$$I_1 = I_0 + \frac{ML^2}{4}$$

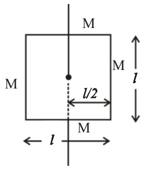
611. Four identical thin rods each of mass M and length *l*, form a square frame. Moment of inertia of this frame about an axis through the centre of the square and perpendicular to its plane is

(a) $\frac{4}{3}Ml^2$ (b) $\frac{2}{3}Ml^2$

(c) $\frac{13}{3}Ml^2$ (d) $\frac{1}{3}Ml^2$

AIPMT- 2009

Ans. (a) : According to question,



By using parallel axis theorem, moment of inertia of each rod about axis

$$\text{M.I.} = 4 \times [\text{M.I. of one rod}]$$

$$\text{M.I.} = 4\left[\frac{1}{12}Ml^2 + \frac{Ml^2}{4}\right]$$

$$\text{M.I.} = 4 \times \frac{1}{3}Ml^2$$

$$\text{M.I.} = \frac{4}{3}Ml^2$$

612. A thin rod of length L and mass M is bent at its mid-point into two halves so that the angle between them is 90°. The moment of inertia of the bent rod about an axis passing through the bending point and perpendicular to the plane defined by the two halves of the rod is

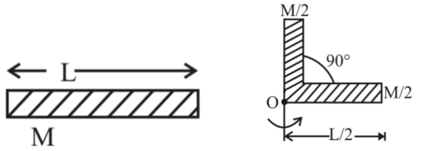
(a) $\frac{ML^2}{24}$ (b) $\frac{ML^2}{12}$

(c) $\frac{ML^2}{6}$ (d) $\frac{\sqrt{2}ML^2}{24}$

AIPMT- 2008

Ans. (b) : According to the question,

Initial Final



Moment of inertia about point O,

$$\text{M.I.} = 2[\text{M.I. of Half rod}]$$

$$\text{M.I.} = 2\left[\frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2\right]$$

$$\text{M.I.} = 2 \times \frac{ML^2}{24}$$

$$\text{M.I.} = \frac{ML^2}{12}$$

613. A circular disc is to be made using iron and aluminium. To keep its moment of inertia maximum about a geometrical axis, it should be so prepared that

(a) aluminium is at the interior and iron surrounds it

(b) iron is at the interior and aluminium surrounds it

(c) aluminium and iron layers are in alternate order

(d) sheet of iron is used at both external surfaces and aluminium sheet as inner material

AIPMT- 2002

Ans. (a) : Moment of inertia of any object or system is depends on distribution of mass.

When mass is more distributed at more distance from centre axis system has more M.I.

Density of iron is more than that of aluminium therefore, the moment of inertia to be maximum, the iron should Bbe far away from the axis. So, iron is at exterior and aluminium is at interior.

@apna_pdf

614. A disc of radius 'R' and thickness $\frac{R}{6}$ has moment of inertia 'I' about an axis passing through its centre and perpendicular to its plane. Disc is melted and recast into a solid sphere. The moment of inertia of a sphere about it diameter is

(a) $\frac{I}{5}$ (b) $\frac{I}{6}$

(c) $\frac{I}{32}$ (d) $\frac{I}{64}$

MHT-CET 2016

Ans. (a) : Given,

Radius of disc = R

Thickness of disc = $\frac{R}{6}$

Let the radius of sphere = r

As the sphere is made from disc,

So, Volume of sphere = Volume of disc

$$\frac{4}{3}\pi r^3 = \pi R^2 \frac{R}{6}$$

$$r^3 = \frac{R^3}{8}$$

$$r = \frac{R}{2}$$

Moment of inertia of sphere,

$$I_s = \frac{2}{5}Mr^2$$

$$I_s = \frac{2}{5}\times M\times\left(\frac{R}{2}\right)^2$$

$$I_s = \frac{2}{5}M\frac{R^2}{4}$$

$$I_s = \frac{MR^2}{10}$$

Since, moment of inertia of disc, $I_d = \frac{1}{2}MR^2$

Therefore, moment of inertia of the sphere

$$I_s = \frac{1}{5}\times I_d = \frac{I}{5}$$

615. A solid cylinder has mass 'M' radius 'R' and length 'ℓ'. Its moment of inertia about an axis passing through its centre and perpendicular to its own axis is

(a) $\frac{2MR^2}{3}+\frac{M\ell^2}{12}$ (b) $\frac{MR^2}{3}+\frac{M\ell^2}{12}$

(c) $\frac{3MR^2}{4}+\frac{M\ell^2}{12}$ (d) $\frac{MR^2}{4}+\frac{M\ell^2}{12}$

MHT-CET 2015

Ans. (d) : Given that,

Mass of cylinder = M

Radius of cylinder = R

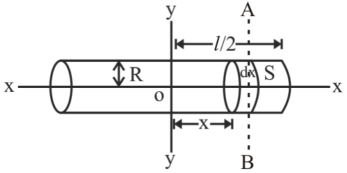
Length of cylinder = l

$\because$ Mass par unit length = $\frac{M}{l}$

Let we form a disc of length dx.

Then, mass of disc $= \frac{M}{l}.dx$

So, Moment of inertia of disc about axis perpendicular to its plane $(I_{AB}) = \left(\frac{M}{l}dx\right)\cdot\frac{R^2}{4}+\left(\frac{m}{l}dx\right)x^2$



Moment of inertia of cylinder by using parallel axis theorem,

$$I = \int_{-l/2}^{l/2}\left(\frac{M}{l}dx\right)\frac{R^2}{4}+\int_{-l/2}^{l/2}\left(\frac{M}{l}dx\right)x^2$$

$$= \frac{M}{l}\left[\int_{-l/2}^{l/2}\left(\frac{R^2}{4}+x^2\right)dx\right]$$

$$= \frac{M}{l}\left[\frac{R^2x}{4}+\frac{x^3}{3}\right]_{-l/2}^{l/2}$$

$$= \frac{M}{l}\left[\frac{R^2\left(\frac{l}{2}\right)}{4}+\frac{\left(\frac{l}{2}\right)^3}{3}\right]-\frac{M}{l}\left[\frac{R^2\times\left(-\frac{l}{2}\right)}{4}+\frac{\left(\frac{-l}{2}\right)^3}{3}\right]$$

$$I = M\left[\frac{R^2}{4}+\frac{l^2}{12}\right]$$

$$\therefore \quad I = \frac{MR^2}{4}+\frac{Ml^2}{12}$$

616. A circular disc is to be made by using iron and aluminium, so that it acquires greater moment of inertia about its geometrical axis. it is possible with

(a) iron and aluminium layers in alternate order
(b) aluminium at interior and iron surrounding it
(c) iron at interior and aluminium surrounding it
(d) Either (a) or (c)

MHT-CET 2011

Ans. (b) : Moment of inertia of any solid depends upon the mass and distance from the centroid axis and is proportional to density. Hence, more the density more will be the mass and thus maximum will be moment of inertia, here density of iron is more than aluminium. The proposed rings made up of iron should be placed at higher radius to get more moment of inertia. To achieve maximum moment of inertia for the circular disc aluminium should be placed at interior and iron at outside.

617. Moment of inertia of a disc about a diameter is I. Find the moment of inertia of disc about an axis perpendicular to its plane and passing through its rim ?

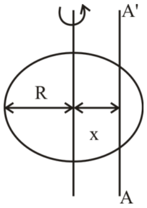
(a) 6 I (b) 4 I

(c) 2 I (d) 8 I

MHT-CET 2010

@apna_pdf

Ans. (a) :
Moment of inertia of a disc about a diameter,



$$I = \frac{1}{4}MR^2$$

$\therefore \quad MR^2 = 4I$

By using parallel axis theorem,

$$I' = I_{CM} + MR^2$$

$$I' = \frac{MR^2}{2} + MR^2 \qquad \left[\because I_{CM} = \frac{MR^2}{2}\right]$$

$$I' = \frac{3}{2}MR^2$$

$$I' = \frac{3}{2} \times 4I \qquad \left[\because MR^2 = 4I\right]$$

$$I' = 6I$$

618. Two spheres of equal masses, one of which is a thin spherical shell and the other a solid, have the same moment of inertia about their respective diameters. The ratio of their radii will be.

(a) 5:7 (b) 3:5

(c) $\sqrt{3}:\sqrt{5}$ (d) $\sqrt{3}:\sqrt{7}$

MHT-CET 2009

Ans. (c) : Given,

Moment of inertia of the spherical shell $I = \frac{2}{3}M R_1^2$ ....(i)

Where, R_1 = radius of the thin spherical shell.
For solid spherical shell,

$$I = \frac{2}{5}MR_2^2 \quad ....(ii)$$

Where, R_2 = radii of the solid sphere.
According to the question,
Both masses and moment of inertia of both the bodies are equal.
So, from equation (i) and (ii) we get,

$$\frac{2}{3}MR_1^2 = \frac{2}{5}MR_2^2$$

$$\frac{R_1^2}{R_2^2} = \frac{3}{5}$$

$$\frac{R_1}{R_2} = \sqrt{\frac{3}{5}}$$

$\therefore \quad R_1 : R_2 = \sqrt{3} : \sqrt{5}$

619. Moment of inertia of a rod of mass M and length L about an axis passing through a point midway between centre and end is

(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{12}$

(c) $\frac{7ML^2}{24}$ (d) $\frac{7ML^2}{48}$

MHT-CET 2009

Ans. (d) : Given, Mass = M, Length = L

$$\text{Distance}(d) = \frac{L}{2} - \frac{L}{4} = \frac{L}{4}$$

We know,

$$I_{CM} = \frac{ML^2}{12}$$

Using parallel axis theorem,

$$I = I_{CM} + Md^2$$

$$= \frac{ML^2}{12} + M\left(\frac{L}{4}\right)^2 = \frac{ML^2}{12} + \frac{ML^2}{16} = \frac{7ML^2}{48}$$

620. Moment of inertia of big drop is I. If 8 droplets are formed from big drop, then moment of inertia of small droplet is

(a) $\frac{I}{32}$ (b) $\frac{I}{16}$

(c) $\frac{I}{8}$ (d) $\frac{I}{4}$

MHT-CET 2009

Ans. (a) :
Moment of inertia of big drop,

$$I = \frac{2}{5}MR^2 \quad ....(i)$$

small droplets are formed from big drop volume of liquid remain same

$$n\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

$$n^{1/3}r = R$$

$\because \quad n = 8$

$\therefore \quad r = \frac{R}{2}$

Since 8 droplets are formed from big drop of mass M.

Mass of each small droplet $= \frac{M}{8}$

Moment of inertia of each small

Droplet $= \frac{2}{5}\left(\frac{M}{8}\right)\left(\frac{R}{2}\right)^2 = \frac{1}{32}\left(\frac{2}{5}MR^2\right)$

$$\text{From equation (i)}, I = \frac{2}{5}MR^2 = \frac{I}{32}$$

621. The moment of inertia of a uniform circular disc of radius R and mass M about an axis touching the disc at its diameter and normal to the disc is

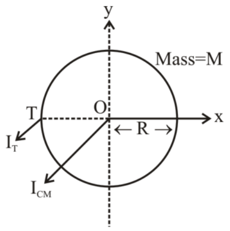
(a) MR^2 (b) $\frac{2}{5}MR^2$

(c) $\frac{3}{2}MR^2$ (d) $\frac{1}{2}MR^2$

MHT-CET 2007

@apna_pdf

Ans. (c) :



The moment of inertia about an axis passing through center of mass of circular disc and perpendicular to its plane is

$$I_{CM} = \frac{1}{2}MR^2$$

From Parallel axis theorem,

$$I_T = I_{CM} + MR^2$$

$$= \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

622. The moment of inertia of a solid sphere about an axis passing through centre of gravity is 2/5 MR^2, then its radius of gyration about a parallel axis at a distance 2 R from first axis is

(a) 5 R (b) $\sqrt{\frac{22}{5}}R$

(c) $\frac{5}{2}R$ (d) $\sqrt{\frac{12}{5}}R$

MHT-CET 2006

Ans. (b) : From parallel axis theorem, the moment of inertia at 2R is

$$I = \frac{2}{5}MR^2 + M(2R)^2$$

$$I = \frac{22}{5}MR^2$$

The radius of gyration,

$$MK^2 = I$$

$$MK^2 = \frac{22}{5}MR^2$$

$$K = \sqrt{\frac{22}{5}}R$$

623. Moment of inertia of a disc about an axis, which is tangent and parallel to its plane, is I. Then the moment of inertia of disc about a tangent, but perpendicular to its plane will be

(a) $\frac{3I}{4}$ (b) $\frac{5I}{6}$

(c) $\frac{3I}{2}$ (d) $\frac{6I}{5}$

MHT-CET 2005

Ans. (d) : Moment of inertia of disc at center of gravity and parallel to its plane.

$$I_{CG} = \frac{MR^2}{4}$$

Moment of inertia of a disc about an axis parallel to its plane,

$$I = I_{CG} + MR^2$$

$$I = \frac{1}{4}MR^2 + MR^2 \quad \text{[By Parallel axis theorem]}$$

$$I = \frac{5}{4}MR^2$$

$$\therefore \quad MR^2 = \frac{4}{5}I$$

Moment of inertia about a tangent perpendicular to its plane,

$$I' = \frac{MR^2}{2} + MR^2$$

$$I' = \frac{3}{2}MR^2$$

Putting the value of $MR^2 = \frac{4}{5}I$

$$I' = \frac{3}{2} \times \frac{4}{5}I$$

$$I' = \frac{6I}{5}$$

624. A round disc of moment of inertia I$_2$ about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I$_1$ rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is–

(a) $\frac{I_2\omega}{I_1 + I_2}$ (b) ω

(c) $\frac{I_1\omega}{I_1 + I_2}$ (d) $\frac{(I_1 + I_2)\omega}{I_1}$

BCECE-2011

Ans. (c) : Moment of inertia I_1, angular momentum of disc rotating about its axis with angular velocity is

$$L_1 = I_1\omega$$

When a round of moment of inertia I_2 is placed of first disc, then angular momentum of the combination is

$$L_2 = (I_1 + I_2)\omega'$$

Angular momentum remain constant in the absence of external torque.

$$L_1 = L_2$$

$$I_1\omega = (I_1 + I_2)\omega'$$

$$\omega' = \frac{I_1\omega}{I_1 + I_2}$$

625. The moment of inertia of a disc of mass M and radius R about a tangent to its rim in its plane is

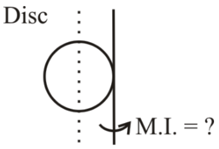
(a) $\frac{2}{3}MR^2$ (b) $\frac{3}{2}MR^2$

(c) $\frac{4}{5}MR^2$ (d) $\frac{5}{4}MR^2$

AIPMT- 1999

@apna_pdf

Ans. (d) :



Apply parallel axis theorem

Moment of Inertia = $I_G + MR^2$

Moment of Inertia = $\frac{1}{4}MR^2 + MR^2$

Moment of Inertia = $\frac{5}{4}MR^2$

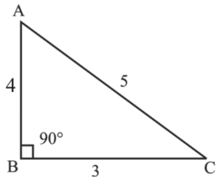
626. ABC is a triangular plate of uniform thickness. The sides are in the ratio shown in the figure. l_{AB}, l_{BC} and l_{CA} are the moments of inertia of the plate about AB, BC and CA as axes respectively. Which one of the following relations is correct?

(a) $l_{AB} > l_{BC}$ (b) $l_{BC} > l_{AC}$

(c) $l_{AB} > l_{BC} = l_{CA}$ (d) l_{AB} is maximum

AIPMT- 1995

Ans. (b) : The intersection of the medians is the center of mass of the triangle. Since the distances of the center of mass from the sides are related to –

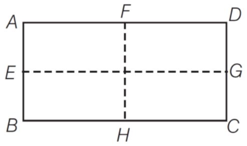


As: $X_{BC} < X_{AB} < X_{AC}$

So,

$I_{BC} > I_{AB} > I_{AC}$

627. In a rectangle ABCD (BC = 2AB). The moment of inertia is minimum along axis through



(a) BC (b) BD

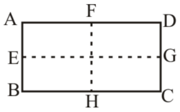
(c) HF (d) EG

AMU PMT-2009

AIPMT- 1993

Ans. (d) : Given,

BC = 2AB



Moment of Inertia ∝ distance of mass distribution

So, Moment of Inertia is minimum along axis EG

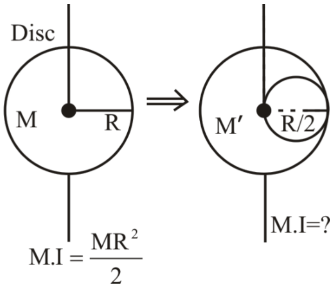
628. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre?

(a) $13\ MR^2/32$ (b) $11\ MR^2/32$

(c) $9\ MR^2/32$ (d) $15\ MR^2/32$

NEET- 2016

Ans. (a) :



Moment of inertia remaining = Moment of inertia of total – Moment of inertia of pickout piece.

Let Disc Area (A) = πR^2

Mass = M

The after cutting

For small piece (A) $= \pi\frac{R^2}{4}$

M' = ?

$\because \frac{M_1}{A_1} = \frac{M_2}{A_2}$ = constant

$$\frac{M}{\pi R^2} = \frac{M'}{\frac{\pi R^2}{4}}$$

$$M' = \frac{M}{4}$$

So, remaining mass $\frac{3M}{4}$

Moment of inertia of cut part about tangential axis = Moment of inertia of cut part at + $M'x^2$ its geometrical axis

$$= \left(\frac{1}{2} \times \frac{M}{4} \times \frac{R^2}{4}\right) + \left(\frac{M}{4} \times \frac{R^2}{4}\right)$$

Moment of inertia of cut part $= \frac{3}{32}MR^2$

So, remaining Moment of inertia of Disc

$$= \frac{1}{2}MR^2 - \frac{3}{32}MR^2 = \frac{13}{32}MR^2$$

@apna_pdf

629. Moment of inertia of a ring of mass *M* and radius *R* about an axis passing through the centre and perpendicular to the plane is T. What is the moment of inertia about its diameter ?

(a) I (b) I/2

(c) $I/\sqrt{2}$ (d) $I+MR^2$

DCE-2009

Ans. (b) : Moment of inertia of ring of mass M and radius R about an axis passing through the centre and perpendicular to the plane,

$$I = MR^2 \quad \text{.....(i)}$$

Moment of inertia of the ring about its diameter

$$I_{diameter} = \frac{MR^2}{2}$$

$$I_{diameter} = \frac{1}{2}(MR^2)$$

$$I_{diameter} = \frac{I}{2}$$

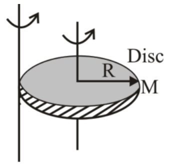
630. The ratio of the radii of gyration of the disc about its axis and about a tangent perpendicular to its plane will be.

(a) $\frac{1}{\sqrt{3}}$ (b) $\sqrt{\frac{3}{2}}$

(c) $\frac{1}{\sqrt{2}}$ (d) $\sqrt{\frac{5}{3}}$

AP EAMCET(Medical)-2015

Ans. (a) :



Moment of inertia about its axis $= \frac{1}{2}MR^2 = MK_1^2$

$$K_1^2 = \frac{R^2}{2}$$

Moment of inertia of disc about its tangent any perpendicular to its plane $= \frac{3}{2}MR^2 = MK_2^2$

$$\because \quad K_2^2 = \frac{3}{2}R^2$$

So,

$$\frac{K_1^2}{K_2^2} = \frac{\frac{R^2}{2}}{\frac{3}{2}R^2}$$

$$\frac{K_1}{K_2} = \frac{1}{\sqrt{3}}$$

631. The radius of gyration of a solid sphere of radius R about a certain axis is also equal to R. If r is the distance between the axis and the centre of the sphere, then r is equal to

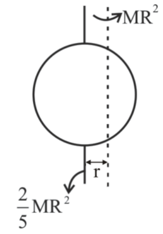
(a) R (b) 0.5 R

(c) $\sqrt{0.6}R$ (d) Zero

AP EAMCET(Medical)-2010

Ans. (c) : Radius of gyration of solid sphere (K) = R

According to question.



$$MK^2 = MR^2$$

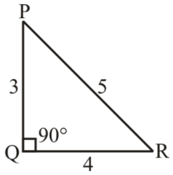
$$I = I_{CM} + mr^2$$

$$MR^2 = \frac{2}{5}MR^2 + Mr^2$$

$$r^2 = \frac{3}{5}R^2$$

$$r = \sqrt{0.6}\,R$$

632. PQR is a right angled triangular plate of uniform thickness as shown in the figure. If I_1, I_2 and I_3 are moments of inertia about PQ, QR and PR axes respectively, then



(a) $I_3 < I_2 < I_1$ (b) $I_1 = I_2 = I_3$

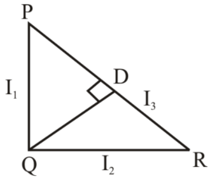
(c) $I_2 > I_1 > I_3$ (d) $I_3 > I_1 > I_2$

AP EAMCET(Medical)-2010

Ans. (c): Moment of inertia a side is = $= \frac{Mh^2}{6}$

Comparison on 3 altitudes

PQ > QR > QD



So, order of moment of inertia about are

QR > PQ > PR

$I_2 > I_1 > I_3$

@apna_pdf

633. A uniform circular disc of radius, R lies in the X-Y plane with its centre coinciding with the origin of the co-ordinate system. Its moment of inertia about an axis, lying in the X-Y plane, parallel to the X-axis and passing through a point on the Y-axis and passing through a point on the Y-axis at a distance y=2R is I_1. Its moment of inertia about an axis lying in a plane perpendicular to X–Y plane passing thought a point on the X-axis at a distance x=d is I_2. If $I_1=I_2$, the value of 'd' is:

(a) $\frac{\sqrt{19}}{2}R$ (b) $\frac{\sqrt{17}}{2}R$

(c) $\frac{\sqrt{15}}{2}R$ (d) $\frac{\sqrt{13}}{2}R$

AP EAMCET(Medical)-2006

Ans. (c) :

$$I_1=\frac{MR^2}{4}+M(2R)^2$$

$$I_1=\frac{MR^2}{4}+4MR^2$$

$$I_1=\frac{17MR^2}{4}$$

$$I_2=\frac{MR^2}{2}+Md^2$$

According to question,

$$I_1=I_2$$

$$\therefore \quad \frac{17MR^2}{4}=\frac{MR^2}{2}+Md^2$$

$$Md^2=\frac{17MR^2}{4}-\frac{MR^2}{2}$$

$$d^2=\frac{15}{4}R^2$$

$$d=\frac{\sqrt{15}}{2}R$$

634. Assertion (A) : I_s and I_H are the moments of inertia about the diameters of a solid and thin walled hollow sphere respectively. If the radii and the masses of the above spheres are equal, $I_H > I_s$.

Reason (R) : In solid sphere, the mass is continuously and regularly distributed about the centre whereas the mass, surface of hollow sphere.

(a) both *A* and *R* and true and *R* is the correct explanation of *A*

(b) both *A* and *R* are true and *R* is not correct explanation of *A*

(c) *A* is true but *R* is false

(d) *A* is false but *R* is true

AP EAMCET(Medical)-2005

Ans. (a) : Because M.I. is directly proportional to distribution of mass.

∵ In Hollow sphere mass is distributed at move distance.

635. A uniform circular disc of radius R lies in the X-Y plane with its centre coincident with the origin. Its moment of inertia about an axis passing through a point of the X-axis at a distance x= 2R and perpendicular to the X-Y plane, is equal to its moment of inertia about an axis passing through a point on the Y-axis at a distance Y = d and parallel to the X-axis in the X-Y plane. The value of d is:

(a) $\frac{4R}{3}$ (b) $\sqrt{17}\left(\frac{R}{2}\right)$

(c) $\sqrt{15}\left(\frac{R}{2}\right)$ (d) $\sqrt{13}\left(\frac{R}{2}\right)$

AP EAMCET(Medical)-2004

Ans. (b) : X-axis at a distance (x) = 2R,

$$I=\frac{MR^2}{2}+M(2R)^2=\frac{9}{2}MR^2$$

Y-axis at a distance d', $I=\frac{MR^2}{4}+Md^2$

According to questions.

$$\frac{9}{2}MR^2=\frac{MR^2}{4}+Md^2$$

$$\frac{9}{2}MR^2-\frac{MR^2}{4}=Md^2$$

$$\frac{18MR^2-MR^2}{4}=Md^2$$

$$\frac{17MR^2}{4}=Md^2$$

$$d^2=\frac{17}{4}R^2$$

$$d=\sqrt{17}\left(\frac{R}{2}\right)$$

@apna_pdf

636. **Two circular loops A and B or radii r_A and r_B respectively are made from a uniform wire. The ratio of their moments of inertia about axes passing through their centers and perpendicular to their planes is $\frac{I_B}{I_A} = 8$, then $\left(\frac{r_B}{r_A}\right)$ equal to**

(a) 2 (b) 4

(c) 6 (d) 8

AP EAMCET(Medical)-2003

Ans. (a) : In question, at its geometrical axis

$$\frac{I_B}{I_A} = 8$$

$$\frac{M_B R_B^2}{M_A R_A^2} = 8$$

Mass = density × Length

$$\frac{\rho R_B R_B^2}{\rho R_A R_A^2} = 8$$

$$\frac{R_B^3}{R_A^3} = 8 \qquad \left(\rho = \frac{m}{v}\right)$$

$$\frac{R_B}{R_A} = 2$$

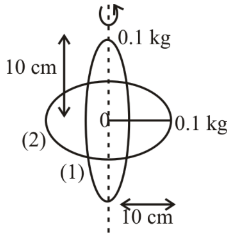
637. **Two thin uniform circular rings each of radius 10 cm and mass 0.1 kg are arranged such that they have common centre and their planes are perpendicular to each other. The moment of inertia of this system about an axis, passing through their common centre and perpendicular to the plane of either of the rings in kg -m^2 is:**

(a) 15×10^{-3} (b) 5×10^{-3}

(c) 15×10^{-4} (d) 18×10^{-4}

AP EAMCET(Medical)-2002

Ans. (c) : According to question



r = 10 cm = 0.1 m

m = 0.1 kg

M.I. of system

$$=(\text{M.I})_1{}^{st}{}_{ring} + (\text{M.I})_2{}^{nd}{}_{ring}$$

$$= \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

$$= \frac{3}{2}\times0.1\times(0.1)^2 = 1.5\times10^{-3}$$

$(\text{M.I.})_{system} = 15\times10^{-4}$

638. **The angular velocity of a body changes from ω_1 to ω_2, without applying a torque but changing moment of inertia. The ratio of corresponding radii of gyration:**

(a) $\omega_1 : \omega_2$ (b) $\sqrt{\omega_1} : \sqrt{\omega_2}$

(c) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (d) $\omega_2 : \omega_1$

AP EAMCET(Medical)-2001

Ans. (c) : According to question

$\tau = 0$

Angular velocity changes from ω_1 to ω_2 by changing M.I.

So, Apply conservation of angular momentum

$$I_1\omega_1 = I_2\omega_2$$

$$\Rightarrow Mk_1^2\omega_1 = Mk_2^2\omega_2$$

$$\left(\frac{k_1}{k_2}\right) = \sqrt{\frac{\omega_2}{\omega_1}}$$

The ratio of $k_1 : k_2$

$$\boxed{k_1 : k_2 = \sqrt{\omega_2} : \sqrt{\omega_1}}$$

639. **A wheel of mass 10 kg has a moment of inertia of 160 kg-m^2 about its own axis. The radius of gyration is :**

(a) 10 m (b) 4 m

(c) 5 m (d) 6 m

AP EAMCET(Medical)-1998

Ans. (b) : M = 10 kg

Moment of Inertia = 160 kg m^2 = MR^2

$MK^2 = MR^2 \qquad [I = MK^2]$

$10 \times K^2 = 160$

$K^2 = 16$

K = 4 meter

640. **A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angular speeds are ω_A and ω_B, respectively. Then**

@apna_pdf

(a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$

(c) $\omega_A = \omega$ (d) $\omega_B = \omega$

BITSAT-2005

Ans. (c) : There will be no transfer of angular momentum between the spheres as there is no friction between the sphere and horizontal surface and also between the sphere themselves from sphere.

Since this is a head on collision between equal masses, then sphere A transfers its linear velocity v to sphere B.

Hence, sphere A will continue to rotate with the same angular speed.

i.e; $\omega_A = \omega$

641. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to the plane with angular velocity ω. Another disc of same mass but half the radius is gently placed over it coaxially. The angular speed of the composite disc will be:

(a) $\left(\frac{5}{4}\right)\omega$ (b) $\left(\frac{4}{5}\right)\omega$

(c) $\left(\frac{2}{5}\right)\omega$ (d) $\left(\frac{5}{2}\right)\omega$

BITSAT-2008

Ans. (b) : Let I_1 and I_2 be the moment of inertia of 1^{st} and 2^{nd} ring respectively

So,

$$I_1 = \frac{MR^2}{2}$$

$$I_2 = I_1 + \frac{M\left(\frac{R}{2}\right)^2}{2}$$

$$= \frac{MR^2}{2} + \frac{MR^2}{8} = \frac{5MR^2}{8}$$

So, angular momentum

$$I_1\,\omega = I_2\,\omega_2$$

$$\frac{MR^2}{2}\omega = \frac{5MR^2}{8}\omega_2$$

$$\omega_2 = \left(\frac{4}{5}\right)\omega$$

642. Which relation is not correct of the following?

(a) Torque = Moment of inertia × angular acceleration

(b) Torque = Dipole moment × magnetic induction

(c) Moment of inertia = Torque × angular acceleration

(d) Angular momentum = Moment of inertia × angular velocity

MHT-CET 2010

Ans. (c): Net torque is the product of moment of inertia and angular acceleration.

Torque = Moment of inertia × angular acceleration

$$\tau = I\alpha$$

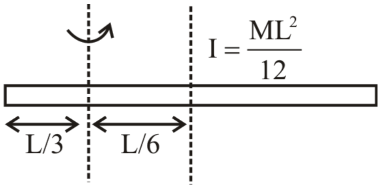
643. The radius of gyration of a rod of length L and mass M about an axis perpendicular to its length and passing through a point at a distance L/3 from one of its ends is

(a) $\frac{\sqrt{7}}{6}L$ (b) $\frac{L^2}{9}$

(c) $\frac{L}{3}$ (d) $\frac{\sqrt{5}}{2}L$

AP EAMCET(Medical)-2007

Ans. (c) :



By parallel axis theorem

$$I = I_{cm} + mx^2$$

$$= \frac{ML^2}{12} + M\left(\frac{L}{6}\right)^2$$

($\because$ Distance of point from centre of mass = $\frac{1}{2} - \frac{1}{3} = \frac{1}{6}$)

$$= \frac{ML^2}{12} + \frac{ML^2}{36}$$

$$= \frac{3ML^2 + ML^2}{36} = \frac{4ML^2}{36}$$

$$I = \frac{ML^2}{9}$$

So, $$Mr^2 = \frac{ML^2}{9}$$

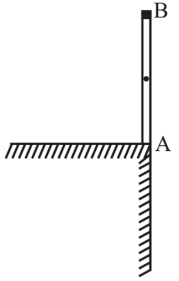
$$r = \sqrt{\frac{L^2}{9}}$$

$$r = L/3$$

@apna_pdf

(e) Equilibrium of Rigid Body

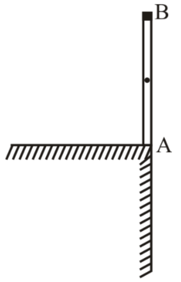
644. A rod AB of length 1m is placed at the edge of a smooth table as shown. It is hit horizontally at point 'B'. If the displacement of centre of mass in 1s is $5\sqrt{2}$m, the angular velocity of rod is ____ (Take g = 10m.s^{-2})



(a) 30 rad.s^{-1} (b) 20 rad.s^{-1}
(c) 10 rad.s^{-1} (d) 5 rad.s^{-1}

AP EAMCET-23.08.2021, Shift-I

Ans. (a) : Given that,



g = 10 ms^{-2}

t = 1s, and displacement of centre of mass = $5\sqrt{2}$

Let V be the velocity of rod in horizontal then,

Displacement of rod in vertical direction in 1s will be.

$$y = \frac{1}{2}gt^2$$

$$y = \frac{1}{2}\times 10\times(1)^2$$

$$y = 5\text{ m}$$

According to question,

$$\sqrt{x^2+y^2} = 5\sqrt{2} \quad \ldots(i) \quad \left[\begin{array}{l}x = \text{Displacement of rod}\\ \text{in horizontal direction}\end{array}\right]$$

$$\left[\text{If, t = 1s then } V = \frac{x}{t} \Rightarrow V = x\right]$$

Squaring both sides of equation (i)

$V^2 + 25 = 50$

$V^2 = 50–25$

$V^2 = 25$

V = 5 m/s

Impulse = change in momentum

$\because \quad J = mv \quad$ ………..(i)

and $J\frac{l}{2} = I.\omega$ ………..(ii) [l = length of rod AB]

Dividing equation (ii) by equation (i)

$$\frac{J\frac{l}{2}}{J} = \frac{I.\omega}{mv}$$

$$\frac{l}{2}\times mv = I\omega$$

$$\omega = \frac{mvl}{2I}$$

$$\omega = \frac{mvl}{2\left(\frac{ml^2}{12}\right)} = \frac{6v}{l} \qquad \left(\because I_{rod} = \frac{ml^2}{12}\right)$$

$$\omega = \frac{6\times 5}{1} = 30\,\text{rad/s}$$

645. A body of mass 2.5 kg is thrown vertically upwards with a kinetic energy of 500 J. The height at which the kinetic energy of the body reduces to 50% of its original value is ______ (g = 10 m. s^{-2})

(a) 10 m (b) 12.5 m
(c) 25 m (d) 50 m

AP EAMCET-05.10.2021, Shift-I

Ans. (a) : Given that, mass (m) = 2.5 kg, K_i = 500 J

We know that, kinetic energy = $\frac{1}{2}mv_o^2$

$$500 = \frac{1}{2}mv_o^2 \qquad \Rightarrow v_o^2 = 400$$

$$v_o = 20$$

$$(K.E.)_2 = 0.5(K.E.)_1$$

$$\frac{1}{2}mv_h^2 = \frac{1}{2}\left(\frac{1}{2}mv_0^2\right) = 250$$

$$v_h^2 = \frac{v_o^2}{2}$$

$$v_h = \frac{20}{\sqrt{2}} = 10\sqrt{2}$$

$$v_h^2 = v_o^2 - 2g\times h$$

$$200 = 400 - 2\times 10\times h$$

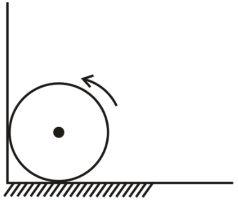
$$200 = 20h$$

$$h = 10\text{m}$$

646. A uniform cylinder of radius 1 m, mass 1kg spins about its axis with an angular velocity 20rad/s. At certain moment, the cylinder is placed into a corner as shown in the figure. The coefficient of friction between the horizontal wall and the cylinder is μ whereas the vertical wall is frictionless. If the number of rounds made by the cylinder is 5 before it stops, then the value μ is

@apna_pdf

(acceleration due to gravity, g = 10 m/s^2)



(a) $\frac{3}{\pi}$ (b) $\frac{2}{\pi}$

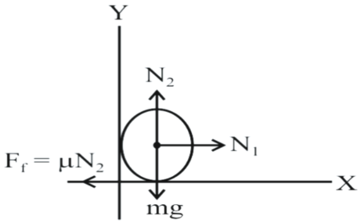
(c) $\frac{1}{\pi}$ (d) $\frac{0.4}{\pi}$

TS-EAMCET-05.05.2018, Shift-1

Ans. (c) : Given that,

$\omega_0 = 20$ rad/s, mass (m) = 1 kg

radius (r) = 1 m



where, F_f = Friction force

$N_2 = mg$ …(i)

$N_1 = \mu N_2 = \mu mg$ ....(ii)

torque about centre of cylinders,

We know that,

$$\text{Torque} = I \times \alpha$$

$$F_f \times R = I \times \alpha$$

$$\mu N_2 R = \frac{mR^2}{2}\alpha \quad ....(iii)$$

$\because$ $N_2 = mg$

$$\mu mg\, R = \frac{mR^2}{2}\alpha$$

$$\alpha = \frac{2\mu g}{R} = \frac{2\mu \times 10}{1} = 20\mu \quad ….(iv)$$

Now from formula,

$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$0 = (20)^2 - 2\left(\frac{2\mu g}{R}\right) \times \theta$$

So, $$0 = (20)^2 - 2\left(\frac{2 \times \mu \times 10}{1}\right)\theta$$

$\because$ $\theta = 5 \times 2\pi = 10\pi$

Again using formula-

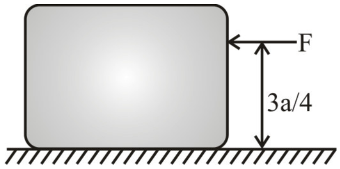
$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$0 = (20)^2 - 2\alpha\theta$$

$$(20)^2 = 40\,\mu\theta$$

$\Rightarrow$ $400 = 40 \times \mu \times 10\pi \Rightarrow \mu = \frac{1}{\pi}$ [from equation (iv)]

647. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point that is directly above the centre of the face, at a height 3a/4 above the base. The minimum value of F for which the cube begins to topple an edge is (assume that cube does not slide)

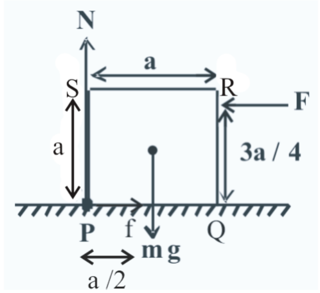


(a) $\frac{mg}{3}$ (b) $\frac{mg}{2}$

(c) $\frac{2mg}{3}$ (d) $\frac{3mg}{4}$

BITSAT-2009

Ans. (c) :



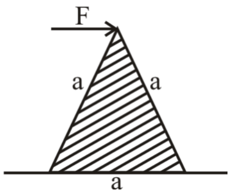
For minimum torque of F about the toppling point (P) should be equal to the torque of weight

So, the net torque about point, i.e. P = 0

$$F \times \frac{3a}{4} = mg \times \frac{a}{2}$$

$$F = \frac{2mg}{3}$$

648. An equilateral prism of mass m rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the prism as shown in the figure. If the coefficient of friction is sufficiently high so that the prism does not slide before toppling, then the minimum force required to topple the prism is-



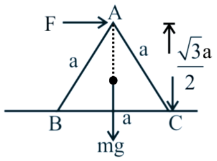
(a) $\frac{mg}{\sqrt{3}}$ (b) $\frac{mg}{4}$

(c) $\frac{\mu mg}{\sqrt{3}}$ (d) $\frac{\mu mg}{4}$

BITSAT-2014

@apna_pdf

Ans. (a) :



$$AP = a\sin 60° = \frac{\sqrt{3}a}{2}$$

The rotation of prism will be about point C.

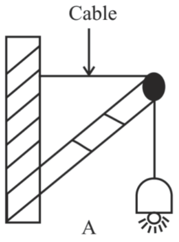
For minimum force the torque of F has to equal to the torque of mg about point C.

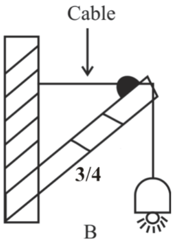
$$F\left(\frac{\sqrt{3}\,a}{2}\right) = mg\left(\frac{a}{2}\right)$$

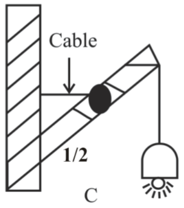
$$F = \frac{mg}{\sqrt{3}}$$

Hence, the minimum force required to topple the prism is $F = \frac{mg}{\sqrt{3}}$

649. If a street light of mass M is suspended from the end of a uniform rod of length L in different possible patterns as shown in figure, then:







(a) Pattern A is more sturdy
(b) Pattern B is more sturdy
(c) Pattern C is more sturdy
(d) All will have same sturdiness

AIIMS-2006

Ans. (a) : If τ be the torque and T be tension in the string and L be perpendicular distance of cable from the axis of rotation then,

$$\tau = T\cdot L$$

Tension is same in all three cases, so the perpendicular distance between the line of action of tension to the axis of rotation.

Now, from the figure we can see that in case A the perpendicular distance is maximum but in other two cases it is less than case A.

Therefore the correct option is (A)

Pattern A is more sturdy.

650. A door 1.6 m wide requires a force of 1 N to be applied at the free end to open or close it. The force that is required at a point 0.4 m distance from the hinges for opening or closing the door is

(a) 1.2 N
(b) 3.6 N
(c) 2.4 N
(d) 4 N

Manipal UGET-2009

Ans. (d) : Given that,

$F = 1N$

$d = 1.6$ m

So, torque, $\tau = F \times d$

$$\tau = 1\times 1.6 \Rightarrow 1.6 Nm$$

Now force is required to open the door at distance 0.4 from hinges point,

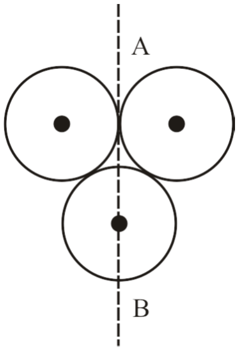
$$\tau = F_1\times d_1$$

$$F_1 = \frac{\tau}{d_1}$$

$$= \frac{1.6}{0.4}$$

$$F_1 = 4N$$

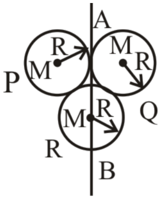
651. Three uniform circular discs, each of mass M and radius R are kept in contact with each other as shown in the figure. Moment of inertia of the system about the axis AB is



(a) $\frac{7}{4}MR^2$
(b) $\frac{11}{4}MR^2$
(c) $\frac{11}{2}MR^2$
(d) $\frac{MR^2}{4}$

AP EAMCET(Medical)-2014

Ans. (b) : According to question –



Moment of inertia of system –

$$= (M.I.)_P + (M.I)_Q + (M.I.)_R$$

$$= \frac{5}{4}MR^2 + \frac{5}{4}MR^2 + \frac{1}{4}MR^2$$

$$(M.I.)_{system} = \frac{11}{4}MR^2$$

@apna_pdf

652. Four particles each of mass m are placed at the corners of a square of side length *l*. The radius of gyration of the system about an axis perpendicular to the square and passing through its centre is:

(a) $\sqrt{2}\ell$ (b) $\frac{\ell}{2}$

(c) l (d) $\frac{l}{\sqrt{2}}$

AP EAMCET(Medical)-2000

Ans. (d) : The distance of mass from center,

$$r = \frac{1}{\sqrt{2}}$$

Moment of inertia, $I = 4\ mr^2$

$$I = 2\ ml^2$$

and $I = 4\ mk^2$

$\therefore\ 2\ ml^2 = 4\ mk^2$

$$k = \frac{l}{\sqrt{2}} \quad \text{(Radius of gyration k)}$$

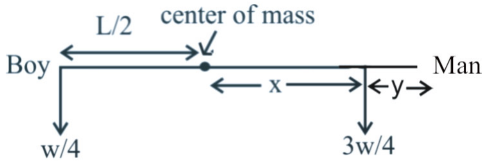
653. A boy and a man carry a uniform rod of length L, horizontally in such a way that boy gets $\frac{1}{4}$th load. If the boy is at one end of the rod, the distance of the man from the other end is

(a) $\frac{L}{3}$ (b) $\frac{L}{4}$

(c) $\frac{2L}{3}$ (d) $\frac{3L}{4}$

JCECE-2010

Ans. (a) : Let, weight of the rod = w, reaction of boy $(R_B) = \frac{w}{4}$, reaction of man $(R_m) = w - \frac{w}{4} = \frac{3w}{4}$



Rotational equilibrium will be equal then,

$$\tau_B = \tau_m$$

$$\frac{w}{4}\times\frac{L}{2} = \frac{3w}{4}\times x$$

$$x = \frac{L}{6}$$

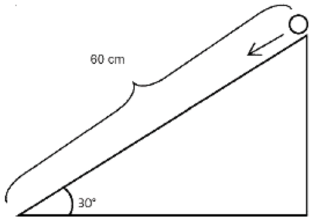
Distance of man from other end (y) = $\frac{L}{2} - x$

$$y = \frac{L}{2} - \frac{L}{6}$$

$$y = \frac{L}{3}$$

(f) Rotational Motion and Rotational Energy

654. A solid cylinder is released from rest from the top of an inclined plane of inclination 30° and length 60 cm. If the cylinder rolls without slipping, its speed upon reaching the bottom of the inclined plane is ______ ms^{-1}



JEE Main-01.02.2023, Shift-I

Ans. (2) :

$$a = \frac{g\sin\theta}{1+\frac{k^2}{r^2}} = \frac{g\sin\theta}{1+\frac{1}{2}} = \frac{2}{3}g\sin\theta = \frac{2}{3}\times10\times\sin30^\circ = \frac{10}{3}m/s$$

We know that,
Third law of motion,

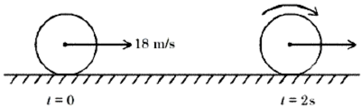
$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2\times\frac{10}{3}\times0.60$$

Then $v^2 = 4$

$v = 2$ m/s

655. A uniform disc of mass 0.5 kg and radius r is projected with velocity 18m/s at t = 0s on a rough horizontal surface. It starts off with a purely sliding motion at t = 0s. After 2s it acquires a purely rolling motion (see figure). The total kinetic energy of the disc after 2s will be_____ J (given, coefficient of friction is 0.3 and g = 10 m/s^2)



JEE Main-30.01.2023, Shift-II

Ans. (54) : We know that,

Force balance in x-axis $\sum F_x = 0$

$$-\mu N = ma$$

$$-0.3\times0.5\times10 = 0.5a$$

$$a = -3\ m/s^2$$

From first law of equation –

$$v = u + at$$

$$v = 18 - 3\times2 = 12\ m/s \quad (\because t = 2\ s)$$

Kinetic energy,

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

@apna_pdf

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}\frac{mR^2}{2}\left(\frac{v}{R}\right)^2$$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$$

$$K.E. = \frac{3}{4}\times 0.5\times(12)^2 = 54J$$

K.E. = 54 J

656. A thin uniform rod of length 2m, cross sectional area 'A' and density 'd' is rotated about an axis passing through the centre and perpendicular to its length with angular velocity ω. If value of ω in terms of its rotational kinetic energy E is $\sqrt{\frac{\alpha E}{Ad}}$ then value of a is _____.

JEE Main-30.01.2023, Shift-I

Ans. (3) : We know that, moment of inertia of rod about center

$$I = \frac{ML^2}{12} = \frac{(d\times A\times 2)\times(2\times 2)}{12} = \frac{2Ad}{3}$$

$$K.E = \frac{1}{2}I\omega^2 = \frac{1}{2}\times\frac{2Ad}{3}\times\omega^2 = E$$

$$\omega = \sqrt{\frac{3E}{Ad}}$$

So α = 3

657. A Solid sphere of mass 2 kg is making pure rolling on a horizontal surface with kinetic energy 2240 J. The velocity of centre of mass of the sphere will be ---ms^{-1}

JEE Main-29.01.2023, Shift-I

Ans. (40) : Total kinetic energy = rolling kinetic energy + translational kinetic energy.

$$KE = \frac{1}{2}1_{cm}\omega^2 + \frac{1}{2}mv^2$$

$$= \frac{1}{2}\times\frac{2}{5}mR^2\times\frac{v^2}{R^2} + \frac{1}{2}mv^2$$

$$\Rightarrow \frac{mv^2}{5} + \frac{mv^2}{2}$$

$$\Rightarrow \frac{7}{10}mv^2 = \frac{7}{10}\times 2\times v^2 = 2240$$

$$v^2 = \frac{22400}{14};\ v = 40m/s$$

658. A solid sphere rolls down two different inclined planes of the same height but of different inclinations.

(a) In both cases the speed and time of descend will be same

(b) The speed will be same but time of descend will be different

(c) The speed will be different but time of descend will be same

(d) Speed and time of descend both will be different

HP CET-2018
AIIMS-2017
AP EAMCET-2011
BCECE-2008
UPCPMT-2006

Ans. (b) : In pure rolling, mechanical energy remains conserved. When heights of incline are equals speed of sphere will be same in both the cases.

As acceleration down to the plane, a ∝ sinθ

Therefore, acceleration and time of descent will be different.

659. A ball of radius R rolls without slipping. Find the fraction of total energy associated with its rotational energy, if the radius of the gyration of the ball about an axis passing through its centre of mass is K.

(a) $\frac{K^2}{(K^2+R^2)}$ (b) $\frac{R^2}{(K^2+R^2)}$

(c) $\frac{(K^2+R^2)}{R^2}$ (d) $\frac{K^2}{R^2}$

JIPMER-2016
BHU-2007
AIPMT-2003

Ans. (a) : We know that,

Kinetic energy of rotation $(K.E.)_{rot.} = \frac{1}{2}I\omega^2$

$$= \frac{1}{2}MK^2\left(\frac{V}{R}\right)^2 \qquad (\because V = R\omega)$$

Where K = radius of gyration

Kinetic energy of translation $(K.E.)_{trans.} = \frac{1}{2}MV^2$

Thus, total energy = $K.E._{rotational} + K.E._{translation}$

$$E = \frac{1}{2}MK^2\frac{V^2}{R^2} + \frac{1}{2}MV^2$$

$$= \frac{1}{2}MV^2\left(\frac{K^2}{R^2}+1\right)$$

$$= \frac{1}{2}\frac{MV^2}{R^2}(K^2+R^2)$$

Fraction of energy,

$$\frac{K.E._{rot}}{K.E._{total}} = \frac{\frac{1}{2}MK^2\frac{V^2}{R^2}}{\frac{1}{2}\frac{MV^2}{R^2}(K^2+R^2)} = \frac{K^2}{K^2+R^2}$$

660. A sphere is rolling on a horizontal surface without slipping. The ratio of the rotational K.E. to the total kinetic energy of the sphere is

@apna_pdf

(a) $\frac{2}{5}$ (b) $\frac{2}{7}$

(c) $\frac{5}{7}$ (d) $\frac{3}{7}$

COMEDK 2016
JCECE-2010
AIPMT-1994

Ans. (b) : We know that,

Rotational kinetic energy $(K.E.)_R = \frac{1}{2} I\omega^2$

For a sphere, moment of inertia $(I) = \frac{2}{5}mr^2$

$$\therefore \quad (K.E.)_R = \frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2} \qquad \left(\omega = \frac{v}{r}\right)$$

$$(K.E.)_R = \frac{1}{5}mv^2$$

Translational kinetic energy $(K.E.)_T = \frac{1}{2}mv^2$

Where $(K.E.)_L$ is translational kinetic energy and $(K.E.)_R$ is rotational kinetic energy

Total K.E. = $(K.E.)_T + (K.E.)_R$

$$\text{Total K.E.} = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$= \frac{5mv^2 + 2mv^2}{10} = \frac{7mv^2}{10}$$

Ratio of rotational kinetic energy to the total kinetic energy of sphere is-

$$\frac{\text{Rotational K.E.}}{\text{Total K.E.}} = \frac{\frac{1}{2}I\omega^2}{\frac{7mv^2}{10}} = \frac{\frac{1}{5}mv^2}{\frac{7mv^2}{10}}$$

$$= \frac{1}{5}\times\frac{10}{7} = \frac{2}{7}$$

661. The moment of inertia of a body about a given axis is 1.2 kg m^2. Initially the body is at rest. In order to produce a rotational kinetic energy of 1500J, an angular acceleration of 25 rad/s^2 must be applied about that axis for a duration of–

(a) 4 s (b) 2 s

(c) 8 s (d) 10 s

Manipal UGET-2013
BCECE-2010
AIPMT-1990

Ans. (b) : Given that, kinetic energy (K.E.) = 1500 J, angular acceleration (α) = 25 rad/sec^2, moment of inertia (I) = 1.2 kg m^2

Kinetic energy of rotation = $\frac{1}{2}\times I\omega^2$

$$1500 = \frac{1}{2}\times 1.2\times\omega^2$$

$$\omega^2 = \frac{1500\times 2}{1.2} = 2500$$

$$\omega = \sqrt{2500} = 50\,\text{rad/sec}$$

From equation of rotation –

$$\omega = \omega_0 + \alpha t \qquad [\omega_0 = 0]$$

$$\omega = \alpha t \qquad [\alpha = 25\ \text{rad/sec}^2]$$

$$50 = 25 \times t$$

$$t = \frac{50}{25} = 2\,\text{sec}$$

662. The angular momentum of a wheel having a rotational inertia of 0.2kg m^2 about its symmetric axis decreases from 4 to 2kg m^2 s^{-1} in 4s. The average power of the wheel is

(a) 7.5 W (b) 15 W

(c) 5 W (d) 12 W

AP EAMCET-05.07.2022, Shift-II

Ans. (a) : Given,

$I = 0.2$ kg m^2
$L_1 = 4$ kg m^2 s^{-1}
$L_2 = 2$ kg m^2 sec^{-1}
$t = 4$ sec

We know that,

$$K.E. = \frac{L^2}{2I}$$

Then,

$$K.E_1 = \frac{L_1^2}{2I}$$

$$K.E_1 = \frac{(4)^2}{2\times 0.2}$$

$$K.E_1 = 40\,J \qquad \text{....(i)}$$

$$K.E_2 = \frac{L_2^2}{2I}$$

$$K.E_2 = \frac{(2)^2}{2\times 0.2}$$

$$K.E_2 = 10\,J \qquad \text{.....(ii)}$$

Power, $P = \frac{\Delta E}{\Delta t}$

$$P = \frac{KE_1 - KE_2}{4}$$

$$P = \frac{40-10}{4} = \frac{30}{4}$$

$$P = 7.5\ W$$

663. A circular disc of weight 500 N and of radius 1 m is started from rest by a constant horizontal force of 25 N applied tangentially to the disc. The kinetic energy of the disc after time t=2 [Acceleration due to gravity =10 ms^{-2}]

(a) 50J (b) 75J

(c) 100J (d) 25J

AP EAMCET-11.07.2022, Shift-II

@apna_pdf

Ans. (a) : Given that,
Weight of disc (W) = 500N
Radius (R) = 1m
Force (F) = 25N

MOI for disc, $I_{disc} = \frac{1}{2}MR^2$

Torque, $\tau = I.\alpha$

$$\alpha = \frac{\tau}{I} = \frac{FR\times2}{MR^2} = \frac{2F}{MR}$$

$$KE = \frac{1}{2}I\omega_f^2 = \frac{1}{2}I(\omega_i+\alpha t)^2$$

$$= \frac{1}{2}\left(\frac{1}{2}MR^2\right)(0+\alpha t)^2$$

$$= \frac{1}{2}\times\left(\frac{1}{2}MR^2\right)(\alpha t)^2$$

$$= \frac{1}{4}MR^2\times\left(\frac{2F}{MR}\right)^2.t^2 = \frac{1}{4}MR^2\times\frac{4\times F^2}{M^2R^2}.t^2$$

$$K.E. = \frac{F^2.t^2}{M}$$

Kinetic energy at t = 2sec.
And weight, W = 500N
Mg = 500
M = 500/10 = 50kg

$$KE = \frac{(25)^2\times4}{50} = \frac{25\times4}{2} = 50J.$$

664. A solid cylinder of radius R is at rest at a height h on an inclined plane. If it rolls down then its velocity on reaching the ground is

(a) $\sqrt{\frac{5gh}{3}}$
(b) $\sqrt{\frac{2h}{3g}}$
(c) $\sqrt{\frac{2gh}{3}}$
(d) $\sqrt{\frac{4gh}{3}}$

AP EAMCET-05.07.2022, Shift-I

Ans. (d): Given that,
Radius = R
Height = h

According to Work Energy theorem,

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid cylinder is

$$I = \frac{1}{2}MR^2$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}\times\frac{1}{2}MR^2\omega^2 \qquad (\because v = R\omega)$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{4}Mv^2$$

$$Mgh = \frac{3}{4}Mv^2$$

$$v^2 = \frac{4}{3}gh$$

$$v = \sqrt{\frac{4gh}{3}}$$

665. The position vector of 1kg object is $\vec{r} = (3\hat{i}-\hat{j})$m and its velocity $\vec{v} = (3\hat{j}+\hat{k})$ms^{-1}. The magnitude of its angular momentum is $\sqrt{x}$N-s Where x is

JEE Main-28.06.2022, Shift-I

Ans. (91) : Given that-

$$\vec{r} = (3\hat{i}-\hat{j})m$$

$$\vec{v} = (3\hat{j}+\hat{k})m/s$$

$$|\tau| = |\vec{r}\times(m\vec{v})| \Rightarrow m|\vec{r}\times\vec{v}|$$

$$= |(3\hat{i}-\hat{j})\times(3\hat{j}+\hat{k})| \qquad [\because m = 1\text{ kg}]$$

$$= \begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 3 & -1 & 0\\ 0 & 3 & 1\end{vmatrix}$$

$$= |-\hat{i}-3\hat{j}+9\hat{k}|$$

$$= \sqrt{(-1)^2+(-3)^2+(9)^2}$$

$$= \sqrt{1+9+81}$$

$$= \sqrt{91}\text{ N-sec.}$$

666. A hydrogen atom is in ground state absorbs 10.2 eV energy. The angular momentum of electron of the hydrogen atom will increase by the value of :
(Given, Planck's constant = 6.6 × 10^{-34} Js)

(a) 2.10 × 10^{-34} Js
(b) 1.05 × 10^{-34} Js
(c) 3.15 × 10^{-34} Js
(d) 4.2 × 10^{-34} Js

JEE Main-27.06.2022, Shift-I

Ans. (b) : Given that,
Energy absorbs in ground = 10.2 eV
Plank's constant = 6.6 × 10^{-34} Js

So, after absorbing, the energy of electron become

$$-13.6 + 10.2 = \frac{-13.6}{n^2}$$

$$-3.4 = \frac{-13.6}{n^2}$$

$$\frac{13.6}{n^2} = 3.4$$

$$n^2 = \frac{13.6}{3.4}$$

$$n^2 = 4$$

$$n = 2$$

Then, Increase in angular momentum given by

$$\Delta L = 2\times\frac{h}{2\pi} - 1\times\frac{h}{2\pi}$$

$$= \frac{6.6\times10^{-34}}{2\times3.14}$$

$$\Delta L \cong 1.05\times10^{-34}\text{ Js.}$$

@apna_pdf

667. A solid spherical ball is rolling on a frictionless horizontal plane surface about its axis of symmetry. The ratio of rotational kinetic energy of the ball to its total kinetic energy is:-

(a) $\frac{2}{5}$ (b) $\frac{2}{7}$

(c) $\frac{1}{5}$ (d) $\frac{7}{10}$

JEE Main-26.06.2022, Shift-II
JIPMER-2005

Ans. (b): When a solid spherical ball is rolling on a frictionless horizontal plane surface.

Then,

$$K.E_{Total} = K.E_{Translation} + K.E_{rotational}$$

$$K.E_{Total} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$v_{cm} = R\omega$, for pure rolling

$$I_{cm} = \frac{2}{5}mR^2 \quad \text{for solid sphere}$$

$$K.E_{Rotational} = \frac{1}{2}I_{cm}\omega^2$$

$$= \frac{1}{2}\times\frac{2}{5}mR^2\times\frac{v_{cm}^2}{R^2}$$

$$= \frac{1}{5}mv_{cm}^2$$

$$K.E_{Total} = \frac{1}{5}mv_{cm}^2 + \frac{1}{2}mv_{cm}^2$$

$$= \frac{7}{10}mv_{cm}^2$$

Hence ratio of K.E. rotational and K.E. total is

$$\frac{K.E_{Rotational}}{K.E_{Total}} = \frac{\frac{1}{5}mv_{cm}^2}{\frac{7}{10}mv_{cm}^2} = \frac{2}{7}$$

668. A fly wheel is accelerated uniformly from rest and rotates through 5 rad in the first second. The angle rotated by the fly wheel in the next second, will be:

(a) 7.5 rad (b) 15 rad

(c) 20 rad (d) 30 rad

JEE Main-24.06.2022, Shift-II

Ans. (b) : Case-I **:-**

Given that,

Angular displacement, $\theta = 5$ rad

Time, $t = 1$ sec.

$\omega_0 = 0$

As the angular acceleration is constant, we have

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = 0 + \frac{1}{2}\alpha t^2$$

$$5 = \frac{1}{2}\alpha(1)^2$$

Angular acceleration, $\alpha = 10$ rad s^{-2}

Case- II **:-**

The angular displacement in first two second is given by

$$\theta' = \frac{1}{2}\times 10\times(2)^2$$

$$\theta' = 20 \text{ rad}$$

Thus, the angle rotated by flywheel during the 2nd second

$$= \theta' - \theta$$
$$= 20 - 5$$
$$= 15 \text{ rad}$$

669. A disc with a flat small bottom beaker placed on it at a distance R from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω. The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ. The beaker will revolve with the disc if :

(a) $R \le \frac{\mu g}{2\omega^2}$ (b) $R \le \frac{\mu g}{\omega^2}$

(c) $R \ge \frac{\mu g}{2\omega^2}$ (d) $R \ge \frac{\mu g}{\omega^2}$

JEE Main-25.06.2022, Shift-II

Ans. (b) : We know that to disc move together –

$$F_s \le F_{s\,max}$$

$$m\omega^2 R \le \mu mg$$

$$\boxed{R \le \frac{\mu g}{\omega^2}}$$

670. A wheel is rotating freely at some angular speed. A second wheel initially at rest and with thrice the rotational inertia of the first, is suddenly coupled to the first wheel. The fraction of the original rotational kinetic energy lost is

(a) 0.50 (b) 0.25

(c) 0.66 (d) 0.75

AP EAMCET-07.07.2022, Shift-I

Ans. (d) : According to law of conservation of angular momentum,

$$I\omega + 0 = I\omega_c + 3I\omega_c$$

$$I\omega = 4I\omega_c$$

$$\omega_c = \frac{\omega}{4}$$

Loss of rotational kinetic energy,

$$(\Delta K.E.)_{loss} = \frac{1}{2}I\omega^2 - \frac{1}{2}(I+3I){\omega_c}^2$$

$$= \frac{1}{2}I\omega^2 - \frac{1}{2}\times 4I\times\frac{\omega^2}{4\times 4}$$

$$= \frac{1}{2}I\omega^2 - \frac{1}{8}I\omega^2$$

@apna_pdf

$$(\Delta KE)_{loss} = \frac{3}{8}I\omega^2$$

Resultant fractional loss in kinetic energy,

$$\frac{(\Delta KE)_{loss}}{(KE)_{initial}} = \frac{\frac{3}{8}I\omega^2}{\frac{1}{2}I\omega^2}$$

$$= \frac{3}{4} = 0.75$$

671. A flywheel having moment of inertia 10 kg.m^2 is rotating at 50 rad.s^{-1}. What amount of work needs to be done in order to bring this flywheel to rest in 10 seconds?

(a) 11400 J
(b) 12500 J
(c) 13000 J
(d) 14500 J

AP EAMCET-24.08.2021, Shift-I

Ans. (b) : Given that,

$I = 10$ kg.m^2

$\omega_0 = 50$ rad/s

From equation we have,

$\omega = \omega_f \Rightarrow 0$, $t = 10$ sec

$\omega = \omega_0 - \alpha t$

$0 = 50 - \alpha \times 10$

$\alpha = 5$ rad/s

$$\because \theta = \omega_0 t - \frac{1}{2}\alpha t^2$$

$$= 50\times10 - \frac{1}{2}\times5\times(10)^2$$

$= 500 - 250$

$= 250$ rad

Retarding torque = $I\alpha = 10 \times 5 = 50$ N-m

Work done by retarding torque

W = Retarding torque × θ

$W = 50 \times 250$

$W = 12500$ J

612. When no external torque acts on a rotating system,

(a) Angular momentum of the system is not conserved
(b) Its rotational kinetic energy is conserved
(c) Its rotational kinetic energy is independent of moment of inertia
(d) Its rotational kinetic energy is directly proportional to moment of inertia
(e) Its rotational kinetic energy is inversely proportional to moment of inertia

Kerala CEE 2021

Ans. (e) : If external torque is zero. Then, angular momentum of system is conserved.

We know,

$$\text{Kinetic energy (K.E.)} = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{I\times\omega^2\times I}{I}$$

$$= \frac{1}{2}\frac{(I\omega)^2}{I}$$

$$= \frac{1}{2}\frac{L^2}{I}$$

$$K.E. \propto \frac{1}{I}$$

However, K.E. is inversely proportional to moment of inertia.

673. If 'R' is the radius of orbit of a satellite, then the kinetic energy of the satellite is_______

(a) $\propto \frac{1}{R}$
(b) $\propto \frac{1}{\sqrt{R}}$
(c) $\propto R$
(d) $\propto \frac{1}{R^{3/2}}$

AP EAMCET-24.08.2021, Shift-II

Ans. (a) : Given, radius of orbit of satellite = R

We know,

$$\text{Kinetic Energy (K.E.)} = \frac{1}{2}mv_0^2$$

Where, v_0 = Orbital velocity

$$\because \quad v_0 = \sqrt{\frac{GM}{R}}$$

Then,

$$K.E. = \frac{1}{2}mv_0^2$$

$$K.E. = \frac{1}{2}m\left(\sqrt{\frac{GM}{R}}\right)^2$$

$$= \frac{GMm}{2R}$$

$$\text{So,} \quad K.E. \propto \frac{1}{R}$$

674. A solid metal ring and a disc of same radius and mass are rotating about their diameters with same angular frequency. The ratio of their respective rotational kinetic energy values is

(a) 1 : 1
(b) 1 : 2
(c) 2 : 1
(d) 1 : 4
(e) 4 : 1

Kerala CEE 2021

Ans. (c) : Let radius of ring = radius of disc = r

Mass of ring = mass of disc = m

Angular frequency of ring = angular frequency of disc = ω

Kinetic energy of solid metal ring

$$K_{ring} = \frac{1}{2}I_{ring}\,\omega_{ring}^2$$

$$K_{ring} = \frac{1}{2}\times mr^2\omega^2$$

Kinetic energy of disc

$$K_{disc} = \frac{1}{2}\times I_{disc}\omega_{disc}^2$$

$$K_{disc} = \frac{1}{2}\times\left(\frac{mr^2}{2}\right)\omega^2$$

@apna_pdf

$$K_{disc} = \frac{1}{4} \times mr^2\omega^2$$

The ratio of their respective rotational kinetic energy is

$$\frac{K_{ring}}{K_{disc}} = \frac{\frac{1}{2}mr^2\omega^2}{\frac{1}{4}mr^2\omega^2}$$

$$\frac{K_{ring}}{K_{disc}} = \frac{2}{1}$$

675. A circular disc is to be made by using equal masses of aluminium and iron. To get maximum moment of inertia, about its geometrical axis, it should be prepared is a way that

(a) Aluminium is at the interior and the iron surrounding it

(b) Iron is at the interior and the aluminium surrounding it

(c) Aluminium and iron are used in alternate layers

(d) Aluminium and iron discs should be kept one above the other.

AP EAMCET-24.08.2021, Shift-II

Ans. (a) : Moment of inertia is depends on distribution of mass about axis of rotation. Density of iron is more than that of aluminium, therefore moment of inertia to be maximum, the iron should be far away from the axis.

Thus, aluminium should be at interior and iron surrounds it.

$$\rho_{iron} > \rho_{Al}$$

∴ Al inside & Iron outside.

676. If the earth stops rotating in its orbit about the sun, there will be variation in the weight of our bodies at _____

(a) Equator (b) 60° latitude

(c) Poles (d) Nowhere

AP EAMCET-20.08.2021, Shift-II

Ans. (d) : If the earth stops revolving in its orbit about the sun there will be variation in the weight of the bodies at nowhere because $g = GM_e/R_e^2$

677. As solid of mass 'M' and radius 'R' spins about an axis passing through its centre making 600 rpm. Its kinetic energy of rotation is

(a) $\frac{2\pi^2}{5}MR$ (b) $\frac{2\pi}{5}M^2R^2$

(c) 80π MR (d) $80\pi^2$ MR^2

AP EAMCET-20.08.2021, Shift-II

Ans. (d) : Given,

$$\text{Angular speed } \omega = 2\pi N = 2\pi \times \frac{600}{60} = 20\pi \text{ rad/s}$$

$$\therefore \text{ Rotational K·E. of the sphere} = \frac{1}{2} I\,\omega^2$$

$$= \frac{1}{2}\cdot\frac{2}{5}MR^2.(20\pi)^2 \quad \left(\because I = \frac{2}{5}MR^2\right)$$

$$= \frac{1}{5}MR^2 \times 400\pi^2, \qquad K.E = 80\pi^2MR^2$$

678. A wheel of mass 10 kg, radius of gyration 50 cm is rotating at 300 rpm. The rotational kinetic energy of the wheel is

(a) 625J (b) 1000J

(c) 1250J (d) 1500J

AP EAMCET-06.09.2021, Shift-II

Ans. (c) : Given,

Mass of wheel (m) = 10kg

Radius of gyration (k) = 50cm = 0.5m

No of Rotation of wheel (N) = 300 rpm

We know that,

$$\omega = \frac{2\pi N}{60} = \frac{2\times\pi\times300}{60} = 10\pi \text{ rad/s}$$

$$K.E. = \frac{1}{2}I\omega^2 = \frac{1}{2}mk^2\omega^2 = \frac{1}{2}\times10\times(0.5)^2\times(10\pi)^2$$

K.E. = 1232.45 ≈ 1250 J

679. A thin uniform rod of mass 1 kg and length 1 m is hanged at one end to the ground floor. It originally stands vertically and allowed to fall ground. If the rod hits the ground with angular speed ω then the correct statement is (Assume g = 10 m/s^2)

(a) $\omega = \sqrt{30}$ rad/s (b) $\omega = \sqrt{20}$ rad/s

(c) $\omega = 5$ rad/s (d) $\omega = 6$ rad/s

TS EAMCET 04.08.2021, Shift-II

Ans. (a) : Given, mass of rod (M) = 1 kg, length of rod (L) = 1 m, angular speed = ω, g = 10 m/s^2

According to law of conservation of energy-

$$Mg\left(\frac{L}{2}\right) + 0 = 0 + \frac{1}{2}I\omega^2$$

$$Mg\frac{L}{2} = \frac{1}{2}\left(\frac{ML^2}{3}\right)\omega^2 \qquad \left[I = \frac{ML^2}{3}\right]$$

$$\frac{3g}{L} = \omega^2$$

$$\omega = \sqrt{\frac{3g}{L}}$$

Putting the value of 'L' and 'g', we get-

$$\omega = \sqrt{\frac{3\times10}{1}} = \sqrt{30}$$

$$\boxed{\omega = \sqrt{30} \text{ rad/sec}}$$

680. A molecule consists of two atoms each of mass 'm' and separated by distance 'd'. At room temperature the average rotational kinetic energy is 'E', then its angular frequency is

(a) $\frac{2}{d}\sqrt{\frac{E}{m}}$ (b) $\sqrt{\frac{m}{Ed}}$

(c) $\frac{d}{2}\sqrt{\frac{m}{E}}$ (d) $\sqrt{\frac{Ed}{m}}$

MHT-CET 2020
MHT-CET-2019

@apna_pdf

Ans. (a) : Given, mass of both atoms = m
separation distance = d
rotational kinetic energy = E
Angular frequency = ?

The moment of inertia of the molecule,

$$I = m\left(\frac{d}{2}\right)^2 + m\left(\frac{d}{2}\right)^2$$

$$I = \frac{md^2}{2} \qquad \text{.....(i)}$$

Rotational Kinetic energy (E) = $\frac{1}{2}I\omega^2$

Putting the value of I from equation (i), we get –

$$E = \frac{1}{2}\times\frac{md^2}{2}\times\omega^2$$

$$\omega^2 = \frac{4E}{md^2}$$

$$\omega = \sqrt{\frac{4E}{md^2}}$$

Angular frequency (ω) = $\frac{2}{d}\sqrt{\frac{E}{m}}$

681. A particle executes uniform circular motion with angular momentum 'L'. Its rotational kinetic energy becomes half, when the angular frequency is doubled. Its new angular momentum is

(a) 4 L
(b) $\frac{L}{4}$
(c) 2L
(d) $\frac{L}{2}$

MHT-CET 2020

Ans. (b) : Suppose that,

Angular momentum (L) = Iω

And

$$\text{Kinetic energy (K)} = \frac{1}{2}I\omega^2$$

$$K = \frac{1}{2}I\omega.\omega$$

$$K = \frac{\omega L}{2} \qquad (L = I\omega)$$

$$L = \frac{2K}{\omega}$$

When angular frequency is doubled and its rotational kinetic energy be comes half.

Frequency (ω') = 2ω and K' = $\frac{K}{2}$

Then, new angular momentum

$$L' = \frac{2\times\left(\frac{K}{2}\right)}{2\omega} = \frac{2K}{4\omega}$$

$$L' = \frac{L}{4}$$

682. Two bodies have their moments of inertia I and 2I respectively about their axes of rotation. If their kinetic energies of rotation are equal, their angular moment will be in the ratio

(a) 1 : 2
(b) 1 : 2√2
(c) 2 : 1
(d) 1 : √2

MHT-CET 2020

Ans. (d) : According to question $(KE)_1 = (KE)_2$

$$\frac{1}{2}I_1\omega_1^2 = \frac{1}{2}I_2\omega_2^2$$

$$I_1\omega_1^2 = I_2\omega_2^2$$

$$\frac{\omega_1^2}{\omega_2^2} = \frac{I_2}{I_1}$$

$$\frac{\omega_1^2}{\omega_2^2} = \frac{2I}{I} \qquad [\because I_1 = I,\ I_2 = 2I]$$

$$\frac{\omega_1}{\omega_2} = \sqrt{\frac{2}{1}}$$

since, angular momentum L = I.ω

$$\frac{L_1}{L_2} = \frac{1}{2}\cdot\frac{\omega_1}{\omega_2}$$

$$= \frac{1}{2}\times\sqrt{\frac{2}{1}}$$

$$L_1 : L_2 = 1 : \sqrt{2}$$

683. A rotating body has angular momentum 'L'. If its frequency of rotation is halved and rotational kinetic energy is doubled, its angular momentum becomes

(a) $\frac{L}{2}$
(b) 4 L
(c) 2 L
(d) $\frac{L}{4}$

MHT-CET 2020

Ans. (b) : Angular momentum, L = Iω

Kinetic energy, K = $\frac{1}{2}I\omega^2$

$$\therefore \quad K = \frac{1}{2}L\omega \qquad (\because\ L = I.\omega)$$

$$L = \frac{2K}{\omega} \qquad \text{.......(i)}$$

When, K' = 2K and ω' = $\frac{\omega}{2}$

Then

$$L' = \frac{2\times(2K)}{\frac{\omega}{2}}$$

$$L' = \frac{4\times 2K}{\omega}$$

$$L' = 4L \qquad \left\{\because L = \frac{2k}{\omega}\right\}$$

@apna_pdf

684. A solid cylinder of mass 'M' and radius 'R' rolls down a smooth inclined plane about its own axis and reaches the bottom with velocity 'v'. The height of the inclined plane is (g = acceleration due to gravity)

(a) $\frac{2v^2}{3g}$ (b) $\frac{7v^2}{9g}$

(c) $\frac{4v^2}{5g}$ (d) $\frac{3v^2}{4g}$

MHT-CET 2020

Ans. (d) : Potential energy of the solid cylinder at height (h) = Mgh

K.E. of center of mass when reached at bottom,

$$\text{K.E.} = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 \qquad [I = MK^2]$$

$$= \frac{1}{2}Mv^2 + \frac{1}{2}MK^2\frac{v^2}{R^2} \qquad [v = R\omega]$$

$$= \frac{1}{2}Mv^2\left(1+\frac{K^2}{R^2}\right)$$; where K is gyration radius

For a solid cylinder , $\frac{K^2}{R^2} = \frac{1}{2}$

K.E. = $\frac{3}{4}Mv^2$

Now, from conservation of energy theorem,

Mgh = $\frac{3}{4}Mv^2$

h = $\frac{3v^2}{4g}$

685. A flywheel of mass 2kg has radius of gyration 0.5 m. If it makes 10 r.p.s. then its rotational kinetic energy will be

(a) $100\pi^2$ erg (b) $50\pi^2$J

(c) $100\pi^2$J (d) $50\pi^2$ erg

MHT-CET 2020

Ans. (c) : Given, mass (m) = 2 kg

Radius of gyration (k) = 0.5m , f = 10 r.p.s

We know that,

Rotational Kinetic Energy $(\text{K.E.})_{\text{rot}} = \frac{1}{2}I\omega^2$

$$= \frac{1}{2}\times mk^2\times(2\pi f)^2 \qquad \begin{bmatrix} I = mk^2 \\ \omega = 2\pi f\end{bmatrix}$$

$$= \frac{1}{2}\times mk^2\times 4\pi^2\times f^2$$

$= 2mk^2\pi^2f^2$

$= 2\times 2\times(0.5)^2\times\pi^2\times(10)^2$

$= 4\times 0.25\times\pi^2\times 100$

$(\text{K.E.})_{\text{rot}} = 100\,\pi^2$ Joule

686. A ring and disc roll on horizontal surface without slipping with same linear velocity. If both have same mass and total kinetic energy of the ring is 4 J then total kinetic energy of the disc is

(a) 3 J (b) 8 J

(c) 6 J (d) 2 J

MHT-CET 2020

MHT-CET 2016

Ans. (a) : Given,

Total kinetic energy of the ring = 4 J

Kinetic energy of rolling body is given by –

$$\text{K.E.} = \frac{1}{2}mv^2\left(1+\frac{k^2}{r^2}\right)$$

$$\frac{(\text{K.E.})_{\text{disc}}}{(\text{K.E.})_{\text{ring}}} = \frac{\frac{1}{2}mv^2\left(1+\frac{k^2}{r^2}\right)}{\frac{1}{2}mv^2\left(1+\frac{k^2}{r^2}\right)}$$

For a ring $\frac{k^2}{r^2} = 1$

For a disc $\frac{k^2}{r^2} = \frac{1}{2}$

$$\frac{(\text{K.E.})_{\text{disc}}}{(\text{K.E.})_{\text{ring}}} = \frac{1+\frac{1}{2}}{1+1} = \frac{\left(\frac{3}{2}\right)}{2} = \frac{3}{4}$$

$(\text{K.E.})_{\text{disc}} = \frac{3}{4}(\text{K.E.})_{\text{ring}}$

$= \frac{3}{4}\times 4$

$(\text{K.E.})_{\text{disc}} = 3$ J

687. A solid sphere of radius r is rolling without sliding. The ratio of rotational kinetic energy and total kinetic energy associated with the sphere is

(a) $\frac{1}{5}$ (b) $\frac{2}{5}$

(c) $\frac{1}{2}$ (d) $\frac{2}{7}$

MHT-CET 2020

Ans. (d) : Total kinetic energy $(\text{K.E.})_{\text{total}} = (\text{K.E.})_{\text{trans}} + (\text{K.E.})_{\text{rot}}$

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid sphere (I) = $\frac{2}{5}mr^2$ and $\omega = \frac{v}{r}$

Rotational kinetic energy, $(\text{K.E.})_{\text{rot}} = \frac{1}{2}I\omega^2$

$$(\text{K.E.})_{\text{rot}} = \frac{1}{2}\times\frac{2}{5}mr^2.\frac{v^2}{r^2}$$

@apna_pdf

$$(\text{K.E.})_{\text{rot}} = \frac{1}{5}mv^2$$

$$(\text{K.E.})_{\text{Total}} = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$(\text{K.E.})_{\text{Total}} = \frac{7}{10}mv^2$$

$$\therefore \quad \frac{(\text{K.E.})_{\text{rot}}}{(\text{K.E.})_{\text{total}}} = \frac{\frac{1}{5}mv^2}{\frac{7}{10}mv^2} = \frac{2}{7}$$

688. A hollow sphere rolls down from the top of inclined plane. Its velocity on reaching the bottom of plane is V_1. When the same sphere slides down from the top of the plane, its velocity on reaching the bottom is V_2. The ratio $V_2 : V_1$ is [Take M.I. of hollow sphere = $\frac{2}{3}MR^2$]

(a) $\sqrt{\frac{5}{3}}$ (b) $\sqrt{\frac{7}{5}}$

(c) $\sqrt{\frac{3}{5}}$ (d) $\sqrt{\frac{5}{7}}$

MHT-CET 2020

Ans. (a) : In first case the hollow sphere is rolling so the potential energy of hollow sphere change into translational and rotational kinetic energy

So, by law of conservation of energy

$$mgh = \frac{1}{2}mv_1^2 + \frac{1}{2}I.\omega^2$$

$$mgh = \frac{1}{2}mv_1^2 + \frac{1}{2}\left(\frac{2}{3}mR^2\right).\left(\frac{v_1}{R}\right)^2 \qquad \because \left(\omega = \frac{V}{R}\right)$$

$$gh = \frac{1}{2}v_1^2 + \frac{1}{2}\left(\frac{2}{3}v_1^2\right)$$

$$gh = \frac{1}{2}v_1^2\left(1 + \frac{2}{3}\right)$$

$$v_1 = \sqrt{\frac{6}{5}gh}$$

When, the hollow sphere slide down then the potential energy changes into translational energy,

i.e. $$mgh = \frac{1}{2}mv_2^2$$

$$v_2 = \sqrt{2gh}$$

Now

$$\frac{v_2}{v_1} = \frac{\sqrt{2gh}}{\sqrt{\frac{6}{5}gh}}$$

$$\frac{v_2}{v_1} = \sqrt{\frac{5}{3}}$$

689. If the earth suddenly contracts to $\left(\frac{1}{3}\right)^{rd}$ of its present size without change in its mass, the ratio of kinetic energy of the earth after and before contraction will be (Earth is assumed to be a sphere)

(a) 3 (b) 9

(c) 7 (d) 5

MHT-CET 2020

Ans. (b) : Mass of earth = M

Radius of earth before contraction = R

Radius of earth after contraction = R/3

$\because$ There is no external torque.

So, by angular conservation of momentum

$$I_1\,\omega_1 = I_2\,\omega_2$$

$$\frac{2}{5}MR^2\omega_1 = \frac{2}{5}M\left(\frac{R}{3}\right)^2.\omega_2$$

$$\frac{\omega_1}{\omega_2} = \frac{1}{9}$$

Now,

$$\frac{K.E_1}{K.E_2} = \frac{\frac{1}{2}I_1\omega_1^2}{\frac{1}{2}I_2\omega_2^2}$$

$$= \frac{\frac{2}{5}MR^2\omega_1^2}{\frac{2}{5}M\left(\frac{R}{3}\right)^2\omega_2^2} = 9\times\left(\frac{\omega_1}{\omega_2}\right)^2$$

$$= 9\times\frac{1}{81} \qquad \left(\because \frac{\omega_1}{\omega_2} = \frac{1}{9}\right)$$

$$\frac{K.E_1}{K.E_2} = \frac{1}{9}$$

or $$\frac{K.E_2}{K.E_1} = 9$$

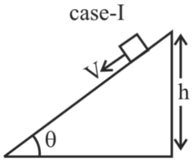
690. A body of mass m slides down a smooth inclined plane of inclination 'θ' and reaches the bottom with velocity 'V'. If the same body is a ring which rolls down the same inclined plane the linear velocity at the bottom of plane is

(a) 2V (b) V

(c) $\frac{V}{\sqrt{2}}$ (d) $\frac{V}{2}$

MHT-CET 2020

Ans. (c) :

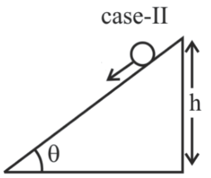


Applying law of conservation of energy-

P.E = K.E

@apna_pdf

$$mgh=\frac{1}{2}mV^2 \qquad ....(i)$$



Let the radius of ring = r

So, $I = mr^2$ and $\omega=\frac{V^1}{r}$

Applying law of conservation of energy-

$$mgh=\frac{1}{2}mV'^2+\frac{1}{2}I\omega^2$$

$$mgh=\frac{1}{2}mV'^2+\frac{1}{2}(mr^2)\left(\frac{V'}{r}\right)^2$$

$$mgh=\frac{1}{2}mV'^2+\frac{1}{2}mV'^2$$

$$mgh=mV'^2 \qquad ....(ii)$$

Equating eq^n. (i) and (ii), we get

$$mV'^2=\frac{1}{2}mV^2$$

$$V'=\frac{V}{\sqrt{2}}$$

691. If 'I' is the moment of inertia and 'L' is angular momentum of a rotating body, then $\frac{L^2}{2I}$ is its

(a) translational kinetic energy
(b) rotational kinetic energy
(c) linear momentum
(d) torque

MHT-CET 2020

Ans. (b) : Let angular velocity of body = ω

Angular momentum of the body, L = Iω

or $\omega=\frac{L}{I}$

Rotational kinetic energy $=\frac{1}{2}I\omega^2$

$$=\frac{1}{2}I\left(\frac{L}{I}\right)^2 \qquad \left\{\because \omega=\frac{L}{I}\right\}$$

$$=\frac{1}{2}\frac{L^2}{I}=\frac{L^2}{2I}$$

692. The moment of inertia of a ring about an axis passing through its centre and perpendicular to its plane is 'I'. It is rotating with angular velocity 'ω'. Another identical ring is gently placed on it so that their centers coincide. If both the ring are rotating about the same axis, then loss in kinetic energy is

(a) $\frac{I\omega^2}{3}$ (b) $\frac{I\omega^2}{4}$
(c) $I\omega^2$ (d) $\frac{I\omega^2}{2}$

MHT-CET 2020, 2018

Ans. (b) : Given that, initial angular momentum (L_1) = Iω, final angular momentum (L_2) = 2Iω'

According to conservation of angular momentum-

$$L_1=L_2$$

$$\therefore \quad I\omega=2I\omega'$$

$$\omega'=\frac{\omega}{2}$$

$$\because \quad K_1=\frac{1}{2}I\omega^2$$

And $\quad K_2=2\times\frac{1}{2}I(\omega')^2=I(\omega')^2$

Putting the value of ω', we get–

$$K_2=I\left(\frac{\omega}{2}\right)^2=\frac{I\omega^2}{4}$$

Since, $\quad \Delta K=K_1-K_2$

$$\Delta K=\frac{1}{2}I\omega^2-\frac{I\omega^2}{4}=\frac{I\omega^2}{4}$$

693. A disc of mass M and radius R rolls without slipping on a level surface with a linear speed v. Its kinetic energy will be given by ________

(a) $\frac{3}{4}Mv^2$ (b) $\frac{4}{3}Mv^2$
(c) $2\ Mv^2$ (d) $3\ Mv^2$

AP EAMCET-24.09.2020, Shift-I

Ans. (a) : Given that,

Mass = M
Radius = R
Speed = v
K.E. = $(K.E.)_{Rotational}+(K.E.)_{Translational}$

$$K.E.=\frac{1}{2}I\omega^2+\frac{1}{2}mv^2$$

Moment of inertia of disc –

$$I=\frac{1}{2}mR^2$$

So,

$$K.E.=\frac{1}{2}\times\frac{1}{2}mR^2\omega^2+\frac{1}{2}mv^2$$

$$K.E.=\frac{1}{4}mv^2+\frac{1}{2}mv^2 \qquad (\because v=R\omega)$$

$$\boxed{K.E.=\frac{3}{4}mv^2}$$

694. A rod of length L revolves in a horizontal plane about the axis passing through its centre and perpendicular to its length. The angular velocity of the rod is ω. If A is the area of cross-section of the rod and ρ is its density, then the rotational kinetic energy of the rod is

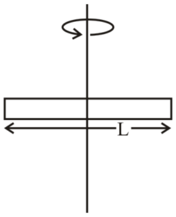
@apna_pdf

(a) $\frac{1}{3}AL^3\rho\omega^2$ (b) $\frac{1}{2}AL^3\rho\omega^2$

(c) $\frac{1}{24}AL^3\rho\omega^2$ (d) $\frac{1}{18}AL^3\rho\omega^2$

TS-EAMCET-11.09.2020, Shift-1

Ans. (c) :



Rotational kinetic energy of rod is given as

$$K_{rot} = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\left(\frac{ML^2}{12}\right)\omega^2$$

$$K_{rot} = \frac{1}{24}ML^2\omega^2 \quad \text{...(i)}$$

But M = volume of rod × density

$$= AL \times \rho \quad \text{...(ii)}$$

$$M = AL\ \rho$$

From equation. (i) and (ii), we have

$$K_{rot} = \frac{1}{24} \times AL\rho \times L^2\omega^2$$

$$K_{rot} = \frac{1}{24}AL^3\rho\omega^2$$

695. A uniform solid sphere of radius R and radius of gyration k about an axis passing through the centre of mass is rolling without slipping. Then, the fraction of total energy associated with its rotation will be

(a) $\frac{(k^2+R^2)}{k^2}$ (b) $\frac{k^2}{R^2}$

(c) $\frac{k^2}{(k^2+R^2)}$ (d) $\frac{R^2}{(k^2+R^2)}$

AP EAMCET (23.09.2020) Shift-I

Ans. (c) : Given,

I_{com} of a solid sphere = mk^2

$$K.E_{Total} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \qquad \left(\because\ \omega = \frac{v}{R}\right)$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mk^2\frac{v^2}{R^2}$$

$$= \frac{1}{2}mv^2\left(1 + \frac{k^2}{R^2}\right)$$

$$\text{Rotational Energy} = \frac{1}{2}I\omega^2$$

$$\text{Fraction} = \frac{\frac{1}{2}I\omega^2}{K.E_{\text{Total}}}$$

$$= \frac{\frac{1}{2}\times mk^2\frac{v^2}{R^2}}{\frac{1}{2}mv^2\left(1+\frac{k^2}{R^2}\right)}$$

$$= \frac{\frac{k^2}{R^2}}{\left(\frac{k^2+R^2}{R^2}\right)}$$

$$F = \left[\frac{k^2}{k^2+R^2}\right]$$

696. Kinetic energy of rotation of a flywheel of radius 2m, mass 8kg and angular speed 4 rad.s^{-1} about an axis perpendicular to its plane and passing through its centre is

(a) 128 J (b) 196 J

(c) 256 J (d) 392 J

AP EAMCET (23.09.2020) Shift-I

Ans. (a) : Given,

R = 2 m

m = 8 kg

ω = 4 rad s^{-1}

So, moment of inertia

$$I = \frac{mR^2}{2}$$

$$= \frac{8\times(2)^2}{2}$$

$$= 16 \text{ kg-m}^2$$

Now, kinetic energy,

$$KE = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\times16\times(4)^2$$

$$K.E = \frac{256}{2} = 128 \text{ J}$$

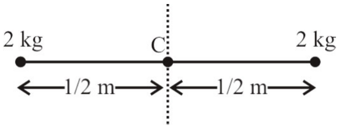
967. A light meter rod has two-point masses each of 2 kg fixed at its ends. If the system rotates about its centre of mass with an angular speed of 0.5 rad s^{-1}, its rotational KE is

(a) 0.125 erg (b) 125 erg

(c) 1.25 J (d) 0.125 J

AP EAMCET (18.09.2020) Shift-II

Ans. (d) : Given,



ω = 0.5 rad s^{-1}

Length of rod, l = 1 m

@apna_pdf

Total mass of light meter road, m = (2 + 2) kg = 4 kg

Then moment of inertia

$$I = 2\times\left(\frac{1}{2}\right)^2 + 2\left(\frac{1}{2}\right)^2$$

$$= \frac{2}{4}+\frac{2}{4} = 1\ \text{kg-m}^2$$

So, Rotational kinetic Energy,

$$K.E_{\text{rotational}} = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\times 1\times(0.5)^2$$

$$= \frac{0.25}{2} = 0.125\ \text{J}$$

968. When a body moves in a circular path, no work is done by the force, since

(a) There is no net force

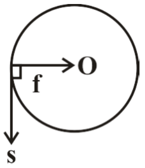
(b) There is no displacement

(c) Force is always away from the centre

(d) Force and displacement are perpendicular to each other

AP EAMCET (17.09.2020) Shift-II

Ans. (d) :



$$\omega = f.s.\cos\theta$$

$$\omega = f.s.\cos 90^o$$

$$\omega = 0$$

When a satellite established ones in an orbit around the earth and it starts revolving with perpendicular speed then no fuel is required for its circular motion.

699. A solid cylinder of mass M and radius R rolls down an inclined plane of height h without slipping. The speed of its centre of mass when it reaches the bottom is

(a) $\sqrt{2gh}$

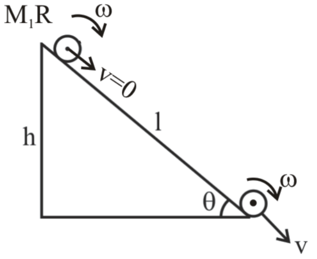
(b) $\sqrt{\frac{4gh}{3}}$

(c) $\sqrt{\frac{3gh}{4}}$

(d) $\sqrt{\frac{4g}{h}}$

VITEEE-2019
AIPMT- 1989

Ans. (b) :



Potential energy of the solid cylinder of mass M and height (h) –

P.E = Mgh

Kinetic energy of center of mass when reached at bottom $= \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

$$= \frac{1}{2}Mv^2 + \frac{M}{2}K^2\frac{v^2}{R^2} \quad \text{(I = in gyration term)}$$

$$= \frac{1}{2}Mv^2\left(1+\frac{K^2}{R^2}\right)$$

Now, for a solid cylinder

$$\frac{K^2}{R^2} = \frac{1}{2}$$

$$K.E = \frac{1}{2}Mv^2\left(1+\frac{1}{2}\right) = \frac{1}{2}Mv^2\times\frac{3}{2}$$

$$K.E = \frac{3}{4}Mv^2$$

$$\therefore\ Mgh = \frac{3}{4}Mv^2$$

$$v = \sqrt{\frac{4gh}{3}}$$

700. A solid cylinder of mass 2 kg and radius 50 cm rolls up an inclined plane of angle inclination 30°. The centre of mass of cylinder has speed of 4 m/s. The distance travelled by the cylinder on the inclined surface will be: (Take g =10m/s^2)

(a) 2.2 m

(b) 1.6 m

(c) 1.2 m

(d) 2.4 m

NEET(Odisha) - 2019

Ans. (d) : Given that,

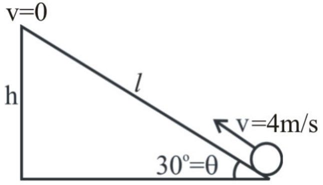
Mass (m) = 2 kg

Radius (r) = 50 cm

Angle of inclination (θ) = 30^o

Speed (v) = 4 m/s

Acceleration due to gravity = 10 m/s^2



From law of conservation of energy-

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mR^2\omega^2 \left(\because I_{\text{solid cylinder}} = \frac{1}{2}mR^2\right)$$

$$mgl\sin 30^o = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 \left(\because \omega = \frac{v}{R}\right)$$

$$l = \frac{3v^2}{4g\sin 30^o} \qquad \because \sin 30^o = \frac{1}{2}$$

$$l = \frac{3\times(v)^2}{4\times 10\times\frac{1}{2}}$$

@apna_pdf

$$l = \frac{3\times4\times4\times2}{4\times10}$$

$$l = \frac{12}{5}$$

$$l = 2.4 \text{ m}$$

701. A wheel of moment of inertia 2 kg m^2 is rotating at a speed of 25 rad/s. Due to friction on the axis, it comes to rest in 10 minutes. Total work done by friction is

(a) 25 J (b) 625 J
(c) 50 J (d) 600 J

MHT-CET 2019

Ans. (b) : Given that, I = 2 kg-m^2, ω = 25 rad / sec, t = 10 min

We know that, total work done by friction to stop wheel–

$$W = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\times2\times(25)^2$$

$$= 625 \text{ J}$$

702. A wheel is rotating freely at an angular speed on a shaft. A second wheel with twice the moment of inertia of the first and initially at rest, is suddenly coupled to the first shaft. If K is the original rotational kinetic energy and ΔK is the loss in rotational kinetic energy, then $\frac{\Delta K}{K}$ is

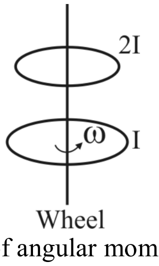
(a) $\frac{1}{4}$ (b) $\frac{3}{4}$
(c) $\frac{3}{5}$ (d) $\frac{2}{3}$

TS EAMCET 08.05.2019, Shift-I

Ans. (d): For 1st wheel For 2nd wheel

$I_1 = I$ $I_2 = 2I$

$\omega_1 = \omega$ $\omega_2 = 0$



Wheel

Apply conservation of angular momentum.

$I\omega = (I + 2I)\,\omega'$

$\omega' = \omega/3$ = common angular velocity

$$\text{Initial K.E} = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2$$

$$\text{K.E} = \frac{1}{2}I\omega^2 + 0 = \frac{1}{2}I\omega^2$$

$$\text{Final K.E.} = \frac{1}{2}3I\left(\frac{\omega}{3}\right)^2 = \frac{1}{6}I\omega^2$$

$$\Delta\text{K.E} = \left(\frac{1}{2}-\frac{1}{6}\right)I\omega^2 = \frac{4}{12}I\omega^2$$

Δ K.E = 1/3 $I\omega^2$

$$\text{So,}\quad \frac{\Delta\text{K.E}}{\text{K.E}} = \frac{\frac{1}{3}I\omega^2}{\frac{1}{2}I\omega^2} = \frac{2}{3}$$

$$\frac{\Delta\text{K.E}}{\text{K.E}} = \frac{2}{3}$$

703. When a ball bounces off the ground, which of the following changes suddenly?
(Assume no loss of energy to the floor)

(a) Its speed (b) Its momentum
(c) Its kinetic energy (d) Its potential energy

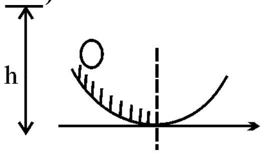
NDA (II) 2019

Ans. (b) : When a ball bounces off the ground, there will be various changes but sudden change will be in momentum because random change in velocity of the ball. It means change in momentum as

$P = mv$

$\Rightarrow$ $P \propto v$

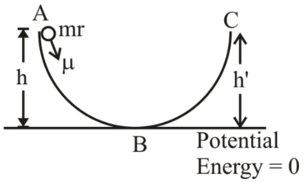
704. A solid spherical ball rolls down a symmetrical bowl starting from rest at the top of the left side (see figure shown) height 'h' from the bottom. If the left half of the bowl is rough and the right half has no friction, the vertical height the ball will reach on the smooth side is (Assuming rolls without slipping in the rough side the bowl)

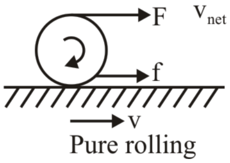


(a) h (b) $\frac{5}{7}h$
(c) $\frac{h}{2}$ (d) $\frac{7}{5}h$

TS EAMCET 09.05.2019, Shift-I

Ans. (b) :





$v_{net} = 0, \Delta x = 0$

$v = r\omega$

$\omega f = \vec{F}.\Delta x = 0$

First we apply

$A \rightarrow B$

@apna_pdf

Energy Conservation

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{r^2} \qquad \because \omega = \frac{v}{r}$$

$$mgh = \frac{1}{2}v^2\left[m + \frac{I}{r^2}\right] \text{.........(i)}$$

Now,

$$B \rightarrow C$$

$$\frac{1}{2}mv^2 = mgh'$$

$$h' = \frac{v^2}{2g} \qquad \text{By equation (i) } v^2 = \frac{2mgh}{\left(m + \frac{I}{r^2}\right)}$$

$$h' = \left[\frac{2mgh}{m + \frac{I}{r^2}}\right] \times \frac{1}{2g} \qquad \left(\because I = \frac{2}{5}MR^2\right)$$

$$h' = \frac{mh}{\left(m + \frac{2}{5}\frac{mr^2}{r^2}\right)}$$

$$h' = \frac{5mh}{7m} = \frac{5h}{7}$$

Ball attained maximum height at out C $= \frac{5h}{7}$

705. Ratio of total kinetic energy and rotational kinetic energy in the motion of a disc is

(a) 1:1 (b) 2:7

(c) 1:2 (d) 3:1

AIIMS-25.05.2019(E) Shift-2

Ans. (d) : Total kinetic energy = Translational K.E. + Rotational K.E.

$$(K.E)_T = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

For a disc, moment of inertia (I) $= \frac{mr^2}{2}$

$$(K.E.)_T = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{mr^2}{2}\times\frac{v^2}{r^2}$$

$$(K.E)_T = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$(K.E)_T = \frac{3}{4}mv^2$$

Rotational kinetic energy $= \frac{1}{2}I\omega^2$

$$(K.E)_R = \frac{1}{2}\times\frac{mr^2}{2}\times\frac{v^2}{r^2} = \frac{1}{4}mv^2$$

Ratio of $(K.E)_T$ and $(K.E)_R$ is –

$$\frac{(K.E)_T}{(K.E)_R} = \frac{\frac{3}{4}mv^2}{\frac{1}{4}mv^2}$$

$$\frac{(K.E)_T}{(K.E)_R} = \frac{3}{1}$$

706. A thin circular disc of mass 12 kg and radius 0.5 m rotates with an angular velocity of 100 rad/s. The rotational kinetic energy of the disc is

(a) 12. 2 kJ (b) 5.5 kJ

(c) 9.2 kJ (d) 7.5 kJ

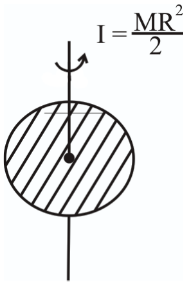
TS-EAMCET-06.05.2019, Shift-1

Ans. (d) : Given ,

Mass of disc (m) = 12 kg

Radius of disc (r) = 0.5 m

Angular velocity (ω) = 100 rad/s



We know that,

Rotational kinetic energy of disc,

$$K.E_R = \frac{1}{2}I\omega^2$$

$$K.E_R = \frac{1}{2}\times\frac{MR^2}{2}\times\omega^2$$

$$K.E_R = \frac{1}{2}\times\frac{12\times0.5\times0.5}{2}\times100\times100$$

$$K.E_R = 3 \times 0.25 \times 100 \times 100$$

$$K.E_R = 7500J$$

$$K.E_R = 7.5 \text{ kJ}$$

Hence, rotational kinetic energy of disc 7.5 kJ

707. Two identical discs are moving with the same kinetic energy. One rolls and the other slides. The ratio of their speeds is

(a) 1 : 2 (b) 1 : 1

(c) 2 : 3 (d) $\sqrt{2}:\sqrt{3}$

AP EAMCET (20.04.2019) Shift-II

Ans. (d) :

Kinetic energy for rolling disc,

$$KE_r = \frac{1}{2}mv_1^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv_1^2 + \frac{1}{2}\frac{mR^2}{2}\left(\frac{v_1}{R}\right)^2 \qquad \left\{\because I = \frac{mR^2}{2}\right\}$$

@apna_pdf

$$KE_r = \frac{3}{4}mv_1^2 \qquad \ldots(i)$$

And, kinetic energy for the sliding disc,

$$\therefore \quad KE_s = \frac{1}{2}mv_2^2 \qquad \ldots(ii)$$

Now, from equation (i) and equation (ii)

$$\frac{3}{4}mv_1^2 = \frac{1}{2}mv_2^2$$

$$3v_1^2 = 2v_2^2$$

$$\text{or} \quad v_1 : v_2 = \sqrt{2} : \sqrt{3}$$

708. The moment of inertia of a ring about an axis passing through the centre and perpendicular to its plane is 'I'. It is rotating with angular velocity 'ω'. Another identical ring is gently placed on it so that their centers coincide. If both the rings are rotating about the same axis then loss in kinetic energy is

(a) $\frac{I\omega^2}{2}$ (b) $\frac{I\omega^2}{4}$

(c) $\frac{I\omega^2}{6}$ (d) $\frac{I\omega^2}{8}$

MHT-CET 2018

Ans. (b) : Given, moment of inertia of 1st ring (I_1) = I

So, moment of inertia of 2nd ring (I_2) = I + I = 2I

By law of conservation of momentum-

$$I_1\,\omega_1 = I_2\,\omega_2$$

$$I\,\omega = 2I\,\omega_2$$

$$\omega_2 = \frac{\omega}{2}$$

$$\therefore \quad K.E = \frac{1}{2}I\omega^2$$

$$\text{So, } (K.E.)_1 = \frac{1}{2}I_1\omega^2 = \frac{1}{2}I\omega^2$$

$$\text{and } (K.E.)_2 = \frac{1}{2}I_2\omega_2^2$$

$$(K.E.)_2 = \frac{1}{2}(2I).\left(\frac{\omega}{2}\right)^2$$

$$= \frac{1}{4}I\omega^2$$

Loss in kinetic energy $(\Delta K.E.) = (K.E.)_1 - (K.E.)_2$

$$= \frac{1}{2}I\omega^2 - \frac{1}{4}I\omega^2$$

$$(\Delta K.E.) = \frac{1}{4}I\omega^2$$

709. The moment of inertia of a body about a given axis is 12 kg-m^2. Initially, the body is at rest. In order to produce a rotational kinetic energy of 15000 J, an angular acceleration of 10 rads^{-2} must be applied about that axis for a duration of

(a) 2 s (b) 4 s

(c) 10 s (d) 5 s

AP EAMCET (23.04.2018) Shift-1

Ans. (d) : Given, I = 12 kg m^2, K.E = 15000 J

α = 10 rad/sec^2

Rotational kinetic energy-

$$K.E. = \frac{1}{2}I\omega^2$$

$$15000 = \frac{1}{2}\times 12\times\omega^2$$

$$\omega = \sqrt{2500} = 50\ \text{rad/sec}$$

Angular acceleration-

$$\omega = \omega_0 + \alpha t \qquad (\because\ \omega_0 = 0)$$

$$t = \frac{\omega}{\alpha} = \frac{50}{10} = 5\,\text{sec}$$

710. Three objects, A: (a solid sphere), B: (a thin circular disk) and C: (a circular ring), each have the same mass M and radius R. They all spin with the same angular speed ω about their own symmetry axes. The amounts of work (W) required to bring them to rest, would satisfy the relation

(a) $W_B > W_A > W_C$ (b) $W_A > W_B > W_C$

(c) $W_C > W_B > W_A$ (d) $W_A > W_C > W_B$

NEET- 2018

Ans. (c) :

Work done = change in K.E

Work done = $K.E_{Rotational} + K.E_{Translational}$

$$\text{Work done} = \frac{1}{2}I\omega^2 + 0$$

$$\text{Work done} = \frac{1}{2}I\omega^2$$

So,

work done is directly proportional to moment of inertia-

Work Done $\propto$ I

We know that-

(I_C) Moment of inertia of circle = MR^2

Moment of inertia of solid sphere $(I_A) = \frac{2}{5}MR^2$

Moment of inertia of Disk $(I_B) = \frac{1}{2}MR^2$

So, $I_C > I_B > I_A$

Hence $W_C > W_B > W_A$

711. A wheel of mass 10 kg and radius 0.8 m is rolling on a road with an angular speed 20 rads^{-1} without sliding. The moment of inertia of the wheel about the axis of rotation is 1.2 kgm^2, then the percentage of rotational kinetic energy in the total kinetic energy of the is —— (approximately)

(a) 5.8% (b) 15.79%

(c) 17% (d) 18.57%

AP EAMCET-25.04.2018, Shift-I

Ans. (b) : Given that-

Mass (m) = 10 kg

Radius (R) = 0.8 m

Angular speed (ω) = 20 rad/sec

@apna_pdf

$$I = 1.2 \text{ kg-m}^2$$

For kinetic energy of rotational

$$K.E_R = \frac{1}{2}I\omega^2$$

$$K.E_R = \frac{1}{2} \times 1.2 \times (20)^2$$

$$K.E_R = \frac{1}{2} \times 1.2 \times 20 \times 20$$

$$K.E_R = 240 \text{ J}$$

For kinetic energy of translation –

$$K.E_T = \frac{1}{2}mv^2$$

$$= \frac{1}{2}m\omega^2r^2 \qquad (\because v = \omega R)$$

$$= \frac{1}{2} \times 10 \times (20)^2 \times (0.8)^2$$

$$= \frac{1}{2} \times 10 \times 20 \times 20 \times 0.8 \times 0.8$$

$$= 1280 \text{ J}$$

Total Kinetic Energy, $K.E' = K.E_T + K.E_R$

$$K.E' = 1280 + 240$$

$$K.E' = 1520$$

Now the ratio –

$$\frac{K.E_R}{K.E'} = \frac{240}{1520}$$

$$= \frac{24}{152} \times 100$$

$$= 15.79\ \%$$

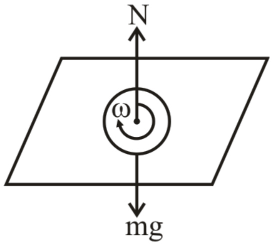
712. A uniform disc of radius R is spinned to an angular velocity ω_o and then carefully placed on a horizontal surface. If pressure exerted by the disc on surface is regarded as uniform and the coefficient of friction is equal to k, the rotation of the disc will come to a stop in time t. The value of t is.

(a) $\frac{R\omega_o}{kg}$ (b) $\frac{3R\omega_o}{4kg}$

(c) $\frac{3R}{4g}\omega_o$ (d) $\frac{3R}{4k}\omega_o$

TS EAMCET (Medical)-02.05.2018, Shift-I

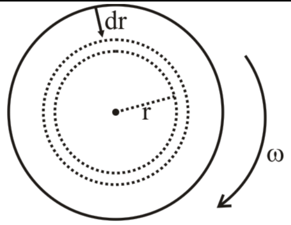
Ans. (b) :



$\therefore \quad N = mg$

$$\frac{\text{Normal by ground}}{\text{Area}} = \frac{N}{\pi R^2} = \frac{mg}{\pi R^2}$$

And $\frac{\text{Mass}}{\text{Area}} = \frac{M}{\pi R^2}$



$$dA = 2\pi r dr$$

$$dm = 2\pi r dr \times \frac{M}{\pi R^2}$$

$$\boxed{dm = \frac{2Mr}{R^2}dr}$$

$$\therefore \quad dN = \frac{N}{\pi R^2} \times 2\pi r dr$$

$$dN = \frac{2Mgr}{R^2}dr \qquad (N = mg)$$

Then $df = (dN)k$

$$df = \frac{2Mgrk}{R^2}dr$$

So, $\int_0^{\tau_0} d\tau_0 = \int (df)r$

$$[\tau_o]_0^{\tau_0} = \int_0^R \frac{2Mgk}{R^2}r^2dr$$

$$\tau_0 = \frac{2Mgk}{R^2}\left[\frac{r^3}{3}\right]_0^R$$

$$\tau_0 = \frac{2Mgk}{R^2} \times \frac{R^3}{3}$$

$$\frac{2MgkR}{3} = I.\alpha = \frac{MR^2}{2}\alpha$$

So, $\alpha = \frac{4gk}{3R}$

$$\frac{d\omega}{dt} = \frac{4gk}{3R}$$

$$-\int_\omega^0 d\omega = \frac{4gk}{3R}\int_0^{t_0} dt$$

$$-[\omega]_\omega^0 = \frac{4gk}{3R}t_0$$

$$\omega_0 = \frac{4gk}{3R}t_0$$

$$\boxed{t_0 = \frac{3R\omega_0}{4gk}}$$

713. The mass of a solid circular disc is 500 g, the circumference is 3.14 m and thickness is 5 mm. The moment of inertia of the disc about an axis tangential to the rim and perpendicular to the plane of rotation is

(a) 100 kgm^2 (b) 0.188 kgm^2

(c) 10 kgm^2 (d) 18.8 kgm^2

Assam CEE-2018

@apna_pdf

Ans. (b) : Given, mass (M) = 500g $= \frac{1}{2}$kg

Circumference = 3.14 m

or $2\pi R = 3.14$

$2 \times 3.14 \times R = 3.14$

$$\text{Radius (R)} = \frac{1}{2}\text{m}$$

According to parallel axis theorem–

$$I_a = I_{cm} + MR^2$$

$$= \frac{MR^2}{2} + MR^2$$

$$= \frac{3}{2}(MR^2)$$

$$= \frac{3}{2} \times \frac{1}{2} \times \left(\frac{1}{2}\right)^2$$

$$= \frac{3}{2} \times \frac{1}{2} \times \frac{1}{4}$$

$$I_a = \frac{3}{16} = 0.188\,\text{kgm}^2$$

714. A flywheel of mass 50 kg is in the form of a disc of diameter 0.5 m. The kinetic energy when it makes 120 revolutions per minute about its axis is ($I = 1/2\ MR^2$)

(a) $50\ \pi^2$ (b) $12.5\ \pi^2$

(c) $25\ \pi^2$ (d) $100\ \pi^2$

JCECE-2018

Ans. (b) : Given,

Mass of flywheel (m) = 50 kg

$$\text{Frequency (f)} = 120 \text{ rev/min} = \frac{120}{60} = 2 \text{ rev/sec}$$

$$\text{Radius (R)} = \frac{d}{2} = \frac{0.5}{2} = 0.25\,\text{m}$$

$\therefore$ Angular velocity (ω) $= 2\pi f$

$$= 2\pi \times 2 = 4\pi \text{ rad/s}$$

$$\text{Moment of inertia of disc (I)} = \frac{1}{2}mR^2$$

$$= \frac{1}{2} \times 50 \times (0.25)^2$$

$$= \frac{1}{2} \times 50 \times 0.0625$$

$$= 1.5625 \text{ kg m}^2$$

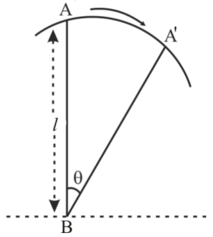
$$\text{Kinetic energy of flywheel (K)} = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2} \times 1.5625 \times 16\pi^2$$

$$= 8 \times 1.5625\ \pi^2$$

$$= 12.5\pi^2$$

715. A uniform rod of length *l* is free to rotate in a vertical plane about a fixed horizontal axis through B. The rod begins rotating from rest from its unstable equilibrium position. When, it has turned through an angle θ, its angular velocity ω given by

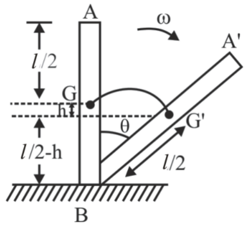


(a) $\sqrt{\left(\frac{6g}{l}\right)}\sin\frac{\theta}{2}$ (b) $\sqrt{\left(\frac{6g}{l}\right)}\cos\frac{\theta}{2}$

(c) $\sqrt{\left(\frac{6g}{l}\right)}\sin\theta$ (d) $\sqrt{\left(\frac{6g}{l}\right)}\cos\theta$

JIPMER-2017

Ans. (a) :



When the rod rotates through angle θ, the fall h of center of gravity is given by,

$$h = \frac{l}{2}(1-\cos\theta)$$

Therefore decrease in potential energy

$$Mgh = Mg\frac{l}{2}(1-\cos\theta)$$

$$\text{Now, kinetic energy of rotation} = \frac{1}{2}I.\omega^2$$

$$= \frac{1}{2} \times \frac{Ml^2}{3}\omega^2$$

$$\text{Moment of inertia about hinged point (I)} = \frac{M\ell^2}{3}$$

According to law of conservation of energy,

Decreases in potential energy = Kinetic energy of rotation

$$\Rightarrow Mg\ \frac{l}{2}(1-\cos\theta) = \frac{1}{2} \times \frac{Ml^2}{3}\omega^2$$

$$3g\ (1-\cos\theta) = l\omega^2$$

$$3g\left(1-1+2\sin^2\frac{\theta}{2}\right) = l\omega^2$$

$$\frac{6g}{l}\sin^2\frac{\theta}{2} = \omega^2$$

$$\omega = \sqrt{\left(\frac{6g}{l}\right)}\ \sin\frac{\theta}{2}$$

@apna_pdf

716. A circular disc rolls down an inclined plane. The ratio of the rotational kinetic energy to the total kinetic energy is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$

(c) $\frac{2}{3}$ (d) $\frac{3}{4}$

UPSEE - 2013

Ans. (b) : Moment of inertia of circular disc $=\frac{1}{2}MR^2$

Rotational K.E= $\frac{1}{2}I.\omega^2=\frac{1}{2}\left(\frac{1}{2}MR^2\right)\times\omega^2 \Rightarrow \frac{1}{4}MR^2\omega^2$

Translational K.E. $=\frac{1}{2}MV^2$

$$=\frac{1}{2}M(R\omega)^2 \qquad [\because V=R\omega]$$

$$\text{Ratio}=\frac{(K.E)_R}{(K.E)_{Total}}$$

$$=\frac{\frac{1}{2}\left(\frac{1}{2}MR^2\omega^2\right)}{\frac{1}{4}MR^2\omega^2+\frac{1}{2}MR^2\omega^2}$$

$$=\frac{\frac{1}{4}}{\frac{1}{4}+\frac{1}{2}} \quad =\frac{\frac{1}{4}}{\frac{3}{4}}=\frac{1}{3}$$

717. A metal sphere of radius r and specific heat s is rotated about an axis passing through its centre at a speed of n rotations per second. It is suddenly stopped and 50% of its energy is used in increasing its temperature. Then the rise in temperature of the sphere is

(a) $\frac{2\pi^2n^2r^2}{5s}$ (b) $\frac{\pi^2n^2}{10r^2s}$

(c) $\frac{7}{8}\pi^2r^2n^2s$ (d) $\frac{5(\pi rn)^2}{14s}$

UPSEE - 2012

Ans. (a) : We know that,

$$\text{Heat } \Delta Q=\frac{1}{2}K.E.$$

$$K.E.=\frac{1}{2}I_{sphere}\omega^2=\frac{1}{2}\left(\frac{2}{5}mr^2\right)(2\pi n)^2 \qquad \left(\because I_{Sphere}=\frac{2}{5}mr^2\right)$$

$$=\frac{4}{5}\pi^2mr^2n^2$$

$\because$ $ms\Delta T=\Delta Q$

$$\Delta T=\frac{K.E.}{2ms}$$

$$\Delta T=\frac{\frac{4}{5}\pi^2mr^2n^2}{2ms}$$

$\therefore$ Rise in temperature, $\Delta T=\frac{2\pi^2n^2r^2}{5s}$

718. A couple produces a :

(a) pure linear motion

(b) pure rotational

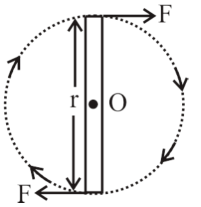
(c) no motion

(d) both linear and rotational motion

UPSEE - 2005

Ans. (b) : A couple consists of two equal and opposite forces acting with two different but parallel line of action.

A pure couple always consists of two forces equal in magnitude.



A couple always produces only rotation

τ = F.r

719. Considering rotational motion of earth. The acceleration due to gravity at the equator of earth is given by, (where ω = angular velocity of earth, R = radius of earth, g = acceleration due to gravity)

(a) $g'=g-\omega R$ (b) $g'=g-\omega R^2$

(c) $g'=g-\omega^2R$ (d) $g'=g+\omega^2R$

CG PET- 2013

Ans. (c) : Due to rotation of earth, the effective value of g is

$$g'=g-\omega^2R\cos^2 0° \qquad \{\text{at equator, } \theta=0°\}$$

$$g'=g-\omega^2R$$

Acceleration due to gravity is zero at the center of the earth. The value of g is least at the equator and maximum at the poles. It means the value of acceleration due to gravity increases as we go from the equator to the poles.

720. A sphere of diameter 0.2 m and mass 2 kg is rolling on an inclined plane with velocity $v = 0.5ms^{-1}$. The kinetic energy of the sphere is

(a) 0.4 J (b) 0.3 J

(c) 0.6 J (d) 0.42 J

JCECE-2014

Ans. (d) : Given, mass of sphere (m) = 2kg, radius of sphere (r) $=\frac{d}{2}=\frac{0.2}{2}=0.1m$,velocity (v) = 0.5 m/sec

Kinetic energy of the sphere while rolling on an inclined plane is given by

K.E. = Translational kinetic energy + Rotational kinetic energy

$$K.E.=\frac{1}{2}mv^2+\frac{1}{2}I\omega^2 \qquad \left\{I=\frac{2}{3}MR^2,\omega=\frac{v}{r}\right\}$$

$$K.E.=\frac{1}{2}\times2\times(0.5)^2+\frac{1}{2}\times\frac{2}{3}\times2\times(0.1)^2\times\left(\frac{0.5}{0.1}\right)^2$$

K.E. = 0.25 + 0.17

K.E. = 0.42 J

@apna_pdf

721. A circular ring of mass m and radius r is rolling on a smooth horizontal surface with speed v. Its kinetic energy is:

(a) $\frac{1}{8}mv^2$ (b) $\frac{1}{4}mv^2$

(c) $\frac{1}{3}mv^2$ (d) mv^2

JCECE-2004

Ans. (b) : We know that,

Rotational kinetic energy (K) = $\frac{1}{2}I\omega^2$

Where, I = moment of inertia, ω = angular velocity

For a circular ring of mass (m), radius (r) and moment of inertia (I) about its diameter is given by –

$$I = \frac{mr^2}{2}$$

Then, $K = \frac{1}{2}\left(\frac{mr^2}{2}\right)\omega^2$

$$K = \frac{1}{2}\left(\frac{mr^2}{2}\right)\left(\frac{v}{r}\right)^2 \qquad \left(\omega = \frac{v}{r}\right)$$

$$K = \frac{1}{4}mr^2 \times \frac{v^2}{r^2}$$

$$K = \frac{1}{4}mv^2$$

722. A ring rolls down an inclined plane. The ratio of rotational kinetic energy to translational kinetic energy is

(a) 1:3 (b) 1:1

(c) 3:1 (d) 2:1

COMEDK 2012

Ans. (b) : For a ring of mass (m), radius (r) and moment of inertia (I) about its diameter is given by

$$I = mr^2$$

We know that, rotational kinetic energy (K_R) = $\frac{1}{2}I\omega^2$

So, $K_R = \frac{1}{2}I\omega^2$

$$K_R = \frac{1}{2}mr^2\left(\frac{v}{r}\right)^2 \qquad \left(\omega = \frac{v}{r}\right)$$

$$K_R = \frac{1}{2}mr^2 \times \frac{v^2}{r^2}$$

$$K_R = \frac{1}{2}mv^2 \qquad ....(i)$$

Translational kinetic energy $(K_T) = \frac{1}{2}mv^2$

Ratio of rotational kinetic energy and translational kinetic energy is–

$$\frac{K_R}{K_T} = \frac{\frac{1}{2}mv^2}{\frac{1}{2}mv^2}$$

Hence, $K_R : K_T = 1 : 1$

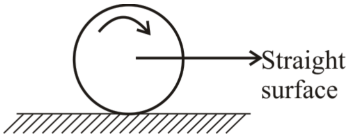
723. A disc is rolling without slipping on a straight surface. The ratio of its translational kinetic energy to its total kinetic energy is

(a) $\frac{2}{3}$ (b) $\frac{1}{3}$

(c) $\frac{2}{5}$ (d) $\frac{3}{5}$

AIIMS-2009

Ans. (a):



Total energy = Translational kinetic energy + Rotational kinetic energy ....(i)

Then, translational kinetic energy $(K.E.)_T = \frac{1}{2}mv^2$

Rotational kinetic energy $(K.E.)_R = \frac{1}{2}I\omega^2$

For disc, moment of inertia (I) = $\frac{mr^2}{2}$

$$(K.E.)_R = \frac{1}{2}I\omega^2 = \frac{1}{2} \times \frac{mr^2}{2} \times \frac{v^2}{r^2} \qquad \left(\omega = \frac{v}{r}\right)$$

$$= \frac{1}{4}mv^2$$

Ratio of its translational kinetic energy to its total Kinetic Energy = $\frac{(K.E.)_T}{(K.E.)_T + (K.E.)_R}$

$$= \frac{\frac{1}{2}mv^2}{\frac{1}{2}mv^2 + \frac{1}{4}mv^2}$$

$$= \frac{\frac{1}{2}mv^2}{\frac{3}{4}mv^2} = \frac{2}{3}$$

724. If a solid sphere of mass 1 kg and radius 0.1 m rolls without slipping at a uniform velocity of 1 m/s along a straight line on a horizontal floor, the kinetic energy is

(a) $\frac{7}{5}$J (b) $\frac{2}{5}$J

(c) $\frac{7}{10}$J (d) 1J

AIIMS-2007

Ans. (c): Given that, mass (m) = 1kg, velocity (v) = 1 ms^{-1}, radius (r) = 0.1 m

When a body is in state of pure rolling the condition which hold is (v = rω) and it has translational kinetic energy as well as rotational kinetic energy

∴ K.E. = Linear K.E. + Rotational K.E.

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

@apna_pdf

For solid sphere, moment of inertia (I) = $\frac{2}{5}mr^2$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\times\left(\frac{v}{r}\right)^2$$

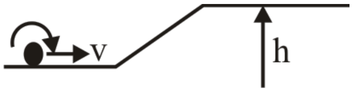
$$K.E. = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$K.E. = \frac{5mv^2 + 2mv^2}{10} = \frac{7mv^2}{10}$$

$$K.E. = \frac{7\times1\times(1)^2}{10}$$

$$K.E. = \frac{7}{10}J$$

725. A solid sphere is rolling on a frictionless surface, shown in figure with translational velocity v m/s. If it is to climb the inclined surface then v should be:

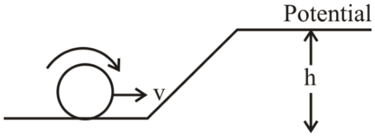


(a) $\geq\sqrt{\frac{10}{7}gh}$ (b) $\geq\sqrt{2gh}$

(c) 2gh (d) $\frac{10}{7}gh$

AIIMS-2005

Ans. (a) :



According to given figure in question to climb the hill the kinetic energy should be greater than the increases in potential energy.

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

For solid sphere, moment of inertia (I) = $\frac{2}{5}mr^2$

$$\frac{1}{2}mv^2 + \frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2} = mgh$$

$$m\left(\frac{v^2}{2} + \frac{v^2}{5}\right) = mgh$$

$$gh = \frac{7v^2}{10}$$

$$v^2 = \frac{10}{7}gh$$

$$v = \sqrt{\frac{10}{7}gh} \text{ or } v \geq \sqrt{\frac{10}{7}gh}$$

726. A hollow sphere of mass 'M' and radius 'R' is rotating with angular frequency 'ω'. It suddenly stops rotating and 75% of kinetic energy is converted to heat. If 'S' is the specific heat of the material in $Jkg^{-1}K^{-1}$ then rise in temperature of the sphere is (M.I. of hollow sphere = $\frac{2}{3}MR^2$)

(a) $\frac{R\omega}{4S}$ (b) $\frac{R^2\omega^2}{4S}$

(c) $\frac{R\omega}{2S}$ (d) $\frac{R^2\omega^2}{2S}$

MHT-CET 2015

Ans. (b): We know that,

Kinetic energy (K.E.) = $\frac{1}{2}I\omega^2$

$$= \frac{1}{2}\times\frac{2}{3}MR^2\omega^2 \quad \left(I = \frac{2}{3}MR^2\right) = \frac{1}{3}MR^2\omega^2$$

According to the question –

75% K.E. = MSΔT

$$\frac{75}{100}\times\frac{1}{3}MR^2\omega^2 = MS\Delta T$$

$$\frac{R^2\omega^2}{4} = S\Delta T$$

$$\Delta T = \frac{R^2\omega^2}{4S}$$

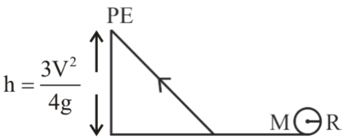
727. An object of radius 'R' and mass 'M' is rolling horizontal without slipping with speed 'V'. It then rolls up the hill to a maximum height $h = \frac{3V^2}{4g}$. The moment of inertia of the object is (g = acceleration due to gravity)

(a) $\frac{2}{5}MR^2$ (b) $\frac{MR^2}{2}$

(c) MR^2 (d) $\frac{3}{2}MR^2$

MHT-CET 2014

Ans. (b) : Given, hill of maximum height (h) = $\frac{3V^2}{4g}$



According to law of conservation of energy –

$$K.E_{(initial)} = P.E_{(final)}$$

$$\frac{1}{2}MV^2 + \frac{1}{2}I\omega^2 = Mgh \quad \left(\therefore \omega = \frac{V}{R}\right)$$

$$\frac{1}{2}MV^2 + \frac{1}{2}I\left(\frac{V^2}{R^2}\right) = Mg\left(\frac{3V^2}{4g}\right)$$

@apna_pdf

$$\frac{1}{2}M+\frac{1}{2}\frac{I}{R^2}=\frac{3M}{4}$$

$$\frac{I}{2R^2}=\left(\frac{3}{4}-\frac{1}{2}\right)M$$

$$\frac{I}{2R^2}=\frac{M}{4}$$

$$I=\frac{M}{4}\times 2R^2$$

$$I=\frac{1}{2}MR^2$$

728. A thin hollow sphere of mass m is completely filled with an ideal liquid of mass m. When the sphere rolls with a velocity v, kinetic energy of the system is equal to:

(a) $\frac{1}{2}mv^2$ (b) mv^2

(c) $\frac{4}{3}mv^2$ (d) $\frac{4}{5}mv^2$

SRMJEE - 2008

Ans. (c) : There are two components of K.E. in this problem. One from translational motion for which both sphere and liquid will contribute giving total linear K.E. as

$$(\text{K.E.})_{\text{linear}}=\frac{1}{2}mv^2+\frac{1}{2}mv^2=mv^2 \quad \text{....(i)}$$

The second component of K.E. will be rotational for which only sphere will contribute (liquid will not rotate) and will be

$$(\text{K.E.})_{\text{rotational}}=\frac{1}{2}I\omega^2=\frac{1}{2}\left(\frac{2}{3}mr^2\right)\left(\frac{v}{r}\right)^2$$

$$=\frac{1}{3}mv^2 \quad \text{....(ii)}$$

$$\because I_{\text{hollow sphere}}=\frac{2}{3}mr^2 \text{ and } \omega=\frac{v}{r}$$

Total K.E. of the system = $(\text{K.E.})_{\text{linear}}+(\text{K.E.})_{\text{rotational}}$

$$=mv^2+\frac{1}{3}mv^2=\frac{4}{3}mv^2$$

729. The ring of radius 1 m and mass 15 kg is rotating about its diameter with angular velocity of 25 rad/sec. Its kinetic energy is

(a) 2040 J (b) 2343.75 J

(c) 1980 J (d) 1680 J

SRMJEE - 2014

Ans. (b) : Given, radius of ring (R) = 1m, mass of ring (M) = 15 kg, angular velocity (ω) = 25 rad/sec

Rotational kinetic energy (K) of body is given by

$$K=\frac{1}{2}I\omega^2 \quad \text{... (i)}$$

Where, I = Moment of inertia

ω = Angular velocity

Moment of inertia of ring rotating about its diameter is given by

$$I=\frac{1}{2}MR^2 \quad \text{... (ii)}$$

Substitute equation (ii) in equation (i), we get

$$K=\frac{1}{2}\left(\frac{1}{2}MR^2\right)\omega^2=\frac{1}{4}\times 15(1)^2\times(25)^2$$

K = 2343.75 J

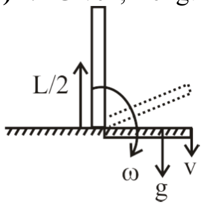
730. A thin rod of length L and mass M is held vertically with one end on the floor and is allowed to fall. The velocity of the other end when it hits the floor, assuming that the end which is on the floor does not slip, will be :

(a) $\sqrt{gL}$ (b) $\sqrt{3gL}$

(c) $\sqrt{\frac{3g}{L}}$ (d) $\frac{1}{2}\sqrt{3gL}$

MP PMT-2013

Ans. (b) : Given, length of rod = L, mass = M



According to law of conservation of energy-

Potential energy = Rotational kinetic energy

$$Mgh=\frac{1}{2}I\omega^2$$

$$Mg\left(\frac{L}{2}\right)=\frac{1}{2}\left(\frac{ML^2}{3}\right)\left(\frac{v}{L}\right)^2$$

$$v=\sqrt{3gL}$$

Hence, velocity of the other end when it hits the floor is $\sqrt{3gL}$.

731. A body is moving in a circular path with acceleration 'a'. If the speed of the body is increased to four times the initial value, the acceleration will become.

(a) 4 a (b) 8 a

(c) 16 a (d) a

MP PET -2013

Ans. (c) : Let, velocity of the object = v

Angular acceleration = a

According to the question-

Speed of body is increased four times then new velocity (v') = 4v

We know that, angular acceleration of any object moving in a circular path, initial acceleration (a) = $\frac{v^2}{r}$

Final acceleration = $\frac{(v')^2}{r}=\frac{(4v)^2}{r}=16\times\frac{v^2}{r}$

Acceleration becomes sixteen times more than initial acceleration.

732. A disc is rolling on the inclined plane, what is the ratio of its rotational K.E. to the total K.E..

(a) 1 : 3 (b) 3 : 1

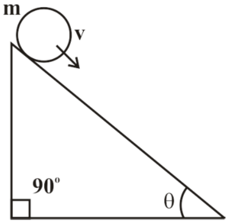
(c) 1 : 2 (d) 2 : 1

DCE-2007

@apna_pdf

Ans. (a) : Total Kinetic Energy = $(K.E.)_{\text{Translational}}$ + $(K.E.)_{\text{rotational}}$

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$



Where,

Moment of Inertia of a disc $I = \frac{1}{2}mr^2$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2$$

$$(\because \ v = r\omega)$$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{4}mr^2\left(\frac{v}{r}\right)^2$$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{4}mr^2 . \frac{v^2}{r^2}$$

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$K.E. = \frac{3}{4}mv^2$$

Rotational Kinetic Energy of the disc

$$(K.E.)_R = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\frac{1}{2}mr^2 . \left(\frac{v}{r}\right)^2$$

$$= \frac{1}{4}mr^2 . \frac{v^2}{r^2}$$

$$\therefore (K.E.)_R = \frac{1}{4}mv^2$$

$$\frac{(K.E.)_R}{(K.E.)_{\text{Total}}} = \frac{\frac{1}{4}mv^2}{\frac{3}{4}mv^2} = \frac{1}{3}$$

$= 1 : 3$

733. A stone is projected vertically up to reach maximum height h. The ratio of its kinetic energy to its potential energy, at a height $\frac{4}{5}h$ will be

(a) 5 : 4
(b) 4 : 5
(c) 1 : 4
(d) 4 : 1

EAMCET-1999

Ans. (c) : At the max height h, velocity (v) = 0

∴ At h, total energy = Potential energy + Kinetic energy (Kinetic energy = 0) = mgh

Now at the given height $\frac{4}{5}h$, using conservation of energy

$$T.E. = P.E. + K.E.$$

$$mgh = mg \times \frac{4}{5}h + K.E.$$

$$K.E. = \frac{mgh}{5}$$

$$\frac{K.E.}{P.E.} = \frac{\frac{1}{5}mgh}{\frac{4}{5}mgh}$$

$$\therefore \quad K.E. : P.E. = \frac{mgh}{5} : \frac{4}{5}mgh$$

$$K.E. : P.E. = 1 : 4$$

734. Assume the earth's orbit around the sun as circular and the distance between their centre as D. Mass of the earth is M and its radius is R. If earth has an angular velocity ω_0 with respect to its centre and ω with respect to the centre of the sun, the total kinetic energy of earth is

(a) $\frac{MR^2\omega_0^2}{5}\left[1 + \left(\frac{\omega}{\omega_0}\right)^2 + \frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$

(b) $\frac{MR^2\omega_0^2}{5}\left[1 + \frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$

(c) $\frac{2}{5}MR^2\omega_0^2\left[1 + \frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$

(d) $\frac{2}{5}MR^2\omega_0^2\left[1 + \left(\frac{\omega}{\omega_o}\right)^2 + \frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$

EAMCET-2006

Ans. (b) : The moment of inertia of a solid sphere,

$$I = \frac{2}{5}MR^2$$

K.E. of earth with respect to its centre

$$(K.E.)_1 = \frac{1}{2}I\omega_0^2 = \frac{1}{2} \times \left(\frac{2}{5}MR^2\right) \times \omega_0^2$$

and K.E. of earth with respect to centre of the Sun

$$(K.E.)_2 = \frac{1}{2}I\omega_0^2 = \frac{1}{2} \times MD^2\omega^2$$

Now, Total K.E. = $(K.E.)_1 + (K.E.)_2$

$$= \frac{1}{2} \times \frac{2}{5}MR^2\omega_0^2 + \frac{1}{2} \times MD^2 . \omega^2$$

$$= \frac{MR^2\omega_0^2}{5}\left[1 + \frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$$

735. A solid sphere is rolling down an inclined plane. Then the ratio of its translational kinetic energy to its rotational kinetic energy is

(a) 2.5
(b) 1.5
(c) 1
(d) 0.4

J&K-CET-2015

@apna_pdf

Ans. (a) : We know that,
For solid sphere Rotational kinetic energy is

$$=\frac{1}{2}I\omega^2 \qquad \left(\because I=\frac{2}{5}mr^2 \text{ for solid sphere}\right)$$

$$(K.E)_{Rotational}=\frac{1}{2}\times\frac{2}{5}mr^2\omega^2$$

$$=\frac{1}{5}mr^2\omega^2 \qquad \left(\because \omega=\frac{v}{r}\right)$$

$$=\frac{1}{5}mr^2\times\frac{v^2}{r^2}$$

$$=\frac{1}{5}mv^2$$

- Translational kinetic energy is given by

$$(K.E)_{Translational}=\frac{1}{2}mv^2$$

According to the question

$$\frac{(K.E)_{Translational}}{(K.E)_{Rotational}}=\frac{\frac{1}{2}\times mv^2}{\frac{1}{5}mv^2}=\frac{5}{2}=2.5$$

736. A fan is moving around its axis. What will be its motion regarded as ?

(a) Pure rolling
(b) Rolling with slipping
(c) Skidding
(d) Pure rotation

UP CPMT-2003

Ans. (d) : A fan is moving around its axis along the pure rotation. It means the body seems to be hinged at some point and free to rotate about the axis passing through that point so consequently every point of the body move in concentric circles having center at the hinged point.

737. A circular disc rolls down an inclined plane without slipping. What fraction of its total energy to translational ?

(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{2}$
(c) $\frac{1}{3}$ (d) $\frac{2}{3}$

Assam CEE-2014

Ans. (d) : We know that, for the rotational kinetic energy –

$$K.E_R=\frac{1}{2}I\omega^2$$

Moment of inertia for disc

$$I=\frac{1}{2}MR^2$$

So,

$$K.E_R=\frac{1}{2}\times\frac{1}{2}MR^2\omega^2$$

$$K.E_R=\frac{1}{4}MR^2\omega^2$$

For the translational kinetic energy –

$$K.E_T=\frac{1}{2}Mv^2$$

$$K.E_T=\frac{1}{2}M(R\omega)^2 \qquad \because v=R\omega$$

$$K.E_T=\frac{1}{2}MR^2\omega^2$$

Now, the total kinetic energy is –

$$K.E=K.E_R+K.E_T$$

$$=\frac{1}{4}MR^2\omega^2+\frac{1}{2}MR^2\omega^2$$

$$=\frac{3}{4}MR^2\omega^2$$

So, the ratio of Translational K.E and total K.E.

$$\frac{K.E_T}{K.E}=\frac{\frac{1}{2}MR^2\omega^2}{\frac{3}{4}MR^2\omega^2}$$

$$\boxed{\frac{K.E_T}{K.E}=\frac{2}{3}}$$

738. A solid cylinder of mass m and radius r rolls without slipping down an inclined plane of length ℓ and height h. The speed of its centre of mass when the cylinder reaches the bottom is

(a) $\sqrt{4gh}$ (b) $\sqrt{\frac{3}{4}gh}$
(c) $\sqrt{2gh}$ (d) $\sqrt{\frac{4}{3}gh}$

Assam CEE-2016
UPSEE - 2014

Ans. (d) : We using the work energy theorem –

$$Mgh=\frac{1}{2}Mv^2+\frac{1}{2}I\omega^2$$

Moment of inertia for solid cylinder,

$$I=\frac{1}{2}MR^2$$

$$Mgh=\frac{1}{2}Mv^2+\frac{1}{2}\times\frac{1}{2}MR^2\omega^2$$

$$Mgh=\frac{1}{2}Mv^2+\frac{1}{4}MR^2\omega^2$$

$$Mgh=\frac{1}{2}Mv^2+\frac{1}{4}Mv^2$$

$$=\frac{3}{4}Mv^2$$

$$\boxed{v=\sqrt{\frac{4}{3}gh}}$$

@apna_pdf

739. The velocity of a solid sphere on reaching the bottom of an inclined plane is v' when it slides down. The value of v/v' will be

(a) $\sqrt{\frac{5}{7}}$ (b) $\sqrt{\frac{7}{5}}$

(c) $\sqrt{\frac{3}{5}}$ (d) $\sqrt{\frac{5}{3}}$

Assam CEE-2016

Ans. (b) : Applying work energy theorem,

$$\text{Total KE} = \Delta KE_{\text{translational}} + \Delta KE_{\text{rotational}}$$

$$\Delta PE = \Delta KE_{\text{translational}} + \Delta KE_{\text{rotational}}$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 \quad \left[\because I_{\text{sphere}} = \frac{2}{5}mR^2\right]$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 \quad [\because v = R\omega]$$

$$Mgh = \frac{7}{10}Mv^2 \quad ....(i)$$

If it slides without friction -

$$Mgh = \frac{1}{2}Mv'^2 \quad ....(ii)$$

From equation (i) and (ii),

$$\frac{1}{2}Mv'^2 = \frac{7}{10}Mv^2$$

$$\frac{v'}{v} = \sqrt{\frac{7\times 2}{10\times 1}} = \sqrt{\frac{7}{5}}$$

740. A thin hollow sphere of mass m is completely filled with a liquid of mass m. When the sphere rolls with a velocity v, kinetic energy of the system is (neglect friction)

(a) $\frac{1}{2}mv^2$ (b) mv^2

(c) $\frac{4}{3}mv^2$ (d) $\frac{4}{5}mv^2$

AP EAMCET -2011

Ans. (c) :

Total energy = $(KE)_{\text{hollow sphere}} + (KE)_{\text{liquid}}$

$$= (KE_{hs})_{\text{Trans}} + (KE_{hs})_{\text{Rot}} + (KE_{\text{liquid}})_{\text{Trans}}$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{3}mr^2\right)\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2$$

$$= \frac{1}{2}(2m)v^2 + \frac{1}{3}mv^2$$

$$= mv^2 + \frac{1}{3}mv^2$$

$$= \frac{4}{3}mv^2$$

741. A ring of radius r and mass m rotates about an axis passing through its centre and perpendicular to its plane, its kinetic energy is

(a) $mr\omega$ (b) $\frac{1}{2}mr\omega^2$

(c) $mr^2\omega^2$ (d) $\frac{1}{2}mr^2\omega^2$

AMU-2002

Ans. (d) : We know that-

Moment of inertia of ring (I) = mr^2

And kinetic energy of rotation = $\frac{1}{2}I\omega^2$

So,

Kinetic energy (K.E.) = $\frac{1}{2}mr^2\omega^2$

742. A solid sphere of mass m and radius R is rotating about its diameter. A solid cylinder of the same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of their kinetic energies of rotation ($E_{\text{sphere}}/E_{\text{cylinder}}$) will be

(a) 2: 3 (b) 1: 5

(c) 1: 4 (d) 3: 1

NEET- 2016

Ans. (b) : Kinetic energy of sphere-

$$(K.E.)_{\text{sphere}} = \frac{1}{2}I\,\omega^2$$

Moment of inertia of sphere-

$$I = \frac{2}{5}mR^2$$

So, $(K.E.)_{\text{sphere}} = \frac{1}{2}\times\frac{2}{5}mR^2\omega^2$

Now, kinetic energy of cylinder-

$$(K.E.)_{\text{cylinder}} = \frac{1}{2}I\,\omega^2$$

Moment of inertia of cylinder-

$$I = \frac{1}{2}mR^2$$

So,

$$(K.E.)_{\text{cylinder}} = \frac{1}{2}\times\frac{1}{2}mR^2\omega^2$$

Given that, $\omega_{\text{cylinder}} = 2\,\omega_{\text{sphere}}$

Hence, the ratio of $(K.E.)_{\text{sphere}}$ and $(K.E.)_{\text{cylinder}}$ is-

$$\frac{(K.E.)_{\text{sphere}}}{(K.E.)_{\text{cylinder}}} = \frac{\frac{1}{5}mR^2\omega^2}{\frac{1}{4}mR^2\omega^2}$$

$$\frac{(K.E.)_{\text{sphere}}}{(K.E.)_{\text{cylinder}}} = \frac{1}{5}$$

$(K.E.)_{\text{sphere}} : (K.E.)_{\text{cylnder}} = 1 : 5$

@apna_pdf

743. Two rotating bodies A and B of masses m and 2m with moments of inertia I_A and I_B ($I_B > I_A$) have equal kinetic energy of rotation. If L_A and L_B be their angular momentum respectively, then

(a) $L_A = \frac{L_B}{2}$ (b) $L_A = 2L_B$

(c) $L_B > L_A$ (d) $L_A > L_B$

NEET- 2016

Ans. (c) : Rotational kinetic energy

$$K_A = \frac{1}{2}I_A\omega_A^2$$

$$K_B = \frac{1}{2}I_B\omega_B^2$$

Then, $I_A\omega_A^2 = I_B\omega_B{}^2$

Angular momentum-

$$L_A = I_A\omega_A \qquad \begin{bmatrix} \because L = I\omega \\ \omega^2 = \frac{L^2}{I^2} \end{bmatrix}$$

$$\omega_A = \frac{L_A}{I_A}$$

$\Rightarrow$ $L_B = I_B\omega_B$

$$\omega_B = \frac{L_B}{I_B}$$

So, $I_A \times \frac{L_A^2}{I_A^2} = I_B \times \frac{L_B^2}{I_B^2}$

$\Rightarrow$ $\frac{L_A^2}{L_B^2} = \frac{I_A}{I_B}$

$$\frac{L_A}{L_B} = \sqrt{\frac{I_A}{I_B}} = \sqrt{\frac{I_A}{I_B}} < 1$$

Then $I_B > I_A$

It means $L_B^2 > L_A^2$

$\Rightarrow$ $L_B > L_A$

744. A disc of mass 4.8kg and radius one meter rolling on a horizontal surface without sliding with angular velocity 600 rotations/min what is total kinetic energy of the disc?

(a) 360 J (b) $1440\pi^2$ J

(c) $4000\pi^2$ J (d) $600\pi^2$ J

AP EMCET(Medical)-2011

Ans. (b) : Given that,

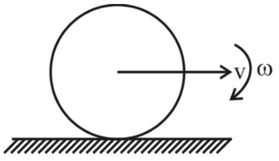
Mass (m) = 4.8 kg

Radius (R) = 1m

Angular velocity, ω = 600 rot/min

$$= \frac{600 \times 2\pi}{60} \text{rad/sec}$$

$$\omega = 20\pi \text{ rad/sec}$$



v = ωR

So,

The kinetic energy of disc which is due to rotation and translation is-

$$\text{K.E.} = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

$(\text{K.E.})_T = (\text{K.E.})_t + (\text{K.E.})_R$

$$\left[\begin{array}{l} (\text{K.E.})_T = \text{Kinetic energy Total} \\ (\text{K.E.})_t = \text{Kinetic energy Translational} \\ (\text{K.E.})_R = \text{Kinetic energy Rotational} \end{array}\right.$$

$$(\text{K.E.})_T = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\frac{mR^2}{2}\omega^2 \qquad \left[\because I = \frac{mR^2}{2}\right]$$

$=$

$$= \frac{3}{4}m\omega^2R^2 \qquad [\because \omega = 600 \text{ rotation/m} = 20\pi \text{ rad/s}]$$

$$= \frac{3}{4} \times 4.8 \times 400\pi^2 \times 1$$

$= 3.6 \times 400 \times \pi^2$

$= 1440\ \pi^2$J

745. Circular disc of mass 2 kg and radius 1 m is to rotating about as axis perpendicular to its plane and passing through its centre of mass with a rotational kinetic energy of 8 J. The angular momentum in (J-s) is

(a) 8 (b) 4

(c) 2 (d) 1

AP EMCET(Medical)-2008

Ans. (b) : Given that,

Mass (m) = 2 kg

Radius (r) = 1m

$(\text{K.E.})_R$ = 8J.

$$I = \frac{mr^2}{2}$$

$$I = \frac{2 \times (1)^2}{2}$$

$$I = 1\text{kg} - \text{m}^2$$

$(\text{K.E.})_R = \frac{1}{2}I\omega^2 = 8$

$\Rightarrow$ $\omega^2 = 8 \times 2$

$\omega^2 = 16$

$\omega = 4\text{rad/sec}$

So, Angular momentum

$L = I\omega = (1) \times 4$

$L = 4$ J-s

@apna_pdf

746. The moment of inertia of a uniform disc about an axis passing through its centre and perpendicular to its plane is 1kg-m^2.It is rotating with an angular velocity 100rad/s. Another identical disc is gently placed on it, so that their centers coincide. Now these two discs together continue to rotate about the same axis. Then the loss in kinetic energy in kilo joule is:

(a) 2.5 (b) 3.0

(c) 3.5 (d) 4.0

AP EAMCET(Medical)-2002

Ans. (a) : Given, $\omega = 100$ rad./sec

Both disc are same so, $I_1 = I_2$

Applying conservation of momentum-

$$I_1\omega = (I_1 + I_2)\omega'$$

$$\omega' = \frac{\omega}{2} \qquad \{\because\ I_1 = I_2 = 1\text{kg}-\text{m}^2\}$$

Loss of kinetic energy-

$$\Delta K.E = \frac{1}{2}I_1\omega^2 - \frac{1}{2}(I_1 + I_2)\omega'$$

$$= \frac{1}{2}\times 1\times(100)^2 - \frac{1}{2}(1+1)\left(\frac{100}{2}\right)^2$$

$$= \frac{1}{2}(10000 - 5000) = \frac{1}{2}\times 5000$$

$$= 2500\text{J}$$

$$= 2.5\text{ KJ} \qquad \{\because\ 1\text{KJ} = 1000\text{J}\}$$

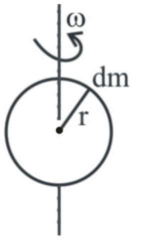
747. A ring of mass m and radius r rotates about an axis passing through its centre and perpendicular to its plane with angular velocity ω. It's kinetic energy is

(a) $\frac{1}{2}mr^2\omega^2$ (b) $mr\omega^2$

(c) $mr^2\omega^2$ (d) $\frac{1}{3}mr^2\omega^2$

AIPMT- 1988

Ans. (a) : Given, mass of ring = m, radius = r, angular velocity = ω



We know that rotational kinetic energy is –

$$K_r = \frac{1}{2}I\omega^2$$

Moment of inertia (I) of ring = mr^2

$$\therefore \quad K_r = \frac{1}{2}\times mr^2\times\omega^2$$

$$K_r = \frac{1}{2}mr^2\omega^2$$

748. Two bodies have their moments of inertia I and 2I respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momentum will be in the ratio

(a) 1: 2 (b) $\sqrt{2}:1$

(c) 2: 1 (d) $1:\sqrt{2}$

AIPMT- 2005

Ans. (d) : Let moment of inertia, $I_1 = I$ and $I_2 = 2I$

According to the question,

$$(K.E.)_1 = (K.E.)_2 \qquad \text{(given)}$$

$$\frac{1}{2}I_1\omega_1^2 = \frac{1}{2}I_2\omega_2^2$$

$$\frac{1}{2}\times I\omega_1^2 = \frac{1}{2}\times 2I\omega_2^2$$

$$\frac{1}{2}I\omega_1^2 = I\omega_2^2$$

$$\left(\frac{\omega_1}{\omega_2}\right)^2 = \frac{2}{1}$$

$$\frac{\omega_1}{\omega_2} = \frac{\sqrt{2}}{1}$$

Now, Ratio of angular momentum –

$$\frac{L_1}{L_2} = \frac{I_1\omega_1}{I_2\omega_2} \qquad [\therefore L = I\omega]$$

$$\frac{L_1}{L_2} = \frac{I_1\times\sqrt{2}}{I_2\times 1} = \frac{I\sqrt{2}}{2I} = \frac{1}{\sqrt{2}}$$

$$L_1 : L_2 = 1 : \sqrt{2}$$

749. A particle performs uniform circular motion with an angular momentum L. If the angular frequency of the particle is doubled, and kinetic energy is halved, its angular momentum becomes:

(a) 4L (b) 2L

(c) $\frac{L}{2}$ (d) $\frac{L}{4}$

AP EAMCET(Medical)-2003

Ans. (d) : Given that,

$$K_2 = \frac{1}{2}K_1$$

$$\omega_2 = 2\omega_1$$

We know that,

$$\text{Kinetic energy}(K) = \frac{1}{2}I\omega^2 \qquad \ldots(i)$$

And Angular momentum (L) = Iω

From equation (i),

$$L = \frac{2K}{\omega}$$

$$L \propto \frac{K}{\omega}$$

@apna_pdf

Now,

$$\frac{L_2}{L_1}=\frac{K_2}{K_1}\times\frac{\omega_1}{\omega_2}=\frac{1}{2}\times\frac{1}{2}$$

Then,

$$\frac{L_2}{L_1}=\frac{1}{4}$$

If $L_1 = L$,

$$L_2=\frac{L}{4}$$

750. A flywheel rotating about a fixed axis has a kinetic energy of 360 J when its angular speed is 30 rad/s. The moment of inertia of the wheel about the axis of rotation is

(a) 0.6 kg –m^2 (b) 0.15 kg –m^2

(c) 0.8 kg –m^2 (d) 0.75 kg –m^2

AIPMT- 1990

Ans. (c) : Given,

Rotational kinetic energy (K.E.) = 360J

Angular speed (ω) = 30 rad/sec

We know that,

Rotational kinetic energy (K.E.) = $\frac{1}{2}I\omega^2$

$$360=\frac{1}{2}\times I\times(30)^2$$

$$I=\frac{720}{900}$$

$$I = 0.8\text{ kg}-\text{m}^2$$

751. A solid cylinder of mass 30 kg rotates about its axis with an angular speed of 50 rad/s. What is the KE associated with the rotation of the cylinder, if the radius of the cylinder is 0.30 m?

(a) 1500.5 J (b) 1687.5 J

(c) 2000.7 J (d) 1350.0 J

J&K-CET-2014

Ans. (b) : Given, M = 30kg, R = 0.30m, ω = 50 rad/s

Kinetic energy of rotating cylinder $=\frac{1}{2}I\omega^2$

For solid cylinder, $I=\frac{MR^2}{2}$

$$=\frac{30\times(0.30)^2}{2}$$

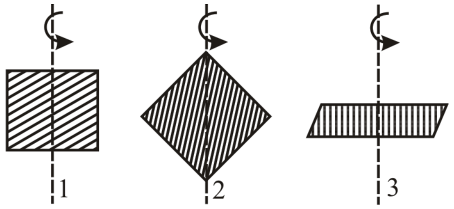
$$=15\times0.09$$

$$=1.35\,\text{kg}\,\text{m}^2$$

∴ Kinetic energy $=\frac{1}{2}\times1.35\times(50)^2$

$$=1687.53\,\text{J}$$

752. Three identical square plates rotate about the axes shown in the figure in such a way that their kinetic energies are equal. Each of the rotation axes passes through the centre of the square. Then the ratio of angular speeds $\omega_1 : \omega_2 : \omega_3$ is

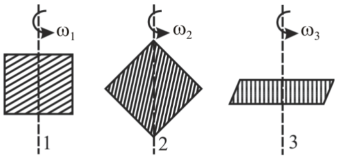


(a) 1 : 1 : 1 (b) $\sqrt{2}:\sqrt{2}:1$

(c) $1:\sqrt{2}:1$ (d) $1:2:\sqrt{2}$

WB JEE-2014

Ans. (b) :



We know that,

Rotational K.E,

$$K=\frac{1}{2}I\omega^2$$

Where, K is kinetic energy,

I = moment of inertia (MOI)

ω = angular speed

When kinetic energy is equal for all (K = constant)

Then, $\omega\propto\frac{1}{\sqrt{I}}$

$$\therefore\quad \omega_1:\omega_2:\omega_3=\frac{1}{\sqrt{I_1}}:\frac{1}{\sqrt{I_2}}:\frac{1}{\sqrt{I_3}}\quad\text{.... (i)}$$

$$I_1=\frac{MR^2}{12}$$

Using perpendicular axis theorem,

$$I_z = I_x + I_y$$

$$I_z = 2I_y \qquad \{\because I_x = I_y\}$$

$$I_y=\frac{1}{2}I_z=\frac{1}{2}.\frac{1}{6}MR^2$$

$$I_2=\frac{1}{12}MR^2 \qquad \{\because I_y = I_2\}$$

$$I_3=\frac{MR^2}{12}+\frac{MR^2}{12}=\frac{MR^2}{6}$$

$$\because\quad \omega_1:\omega_2:\omega_3=\frac{1}{\sqrt{I_1}}:\frac{1}{\sqrt{I_2}}:\frac{1}{\sqrt{I_3}}$$

$$=\sqrt{\frac{12}{MR^2}}:\sqrt{\frac{12}{MR^2}}:\sqrt{\frac{6}{MR^2}}$$

$$\omega_1:\omega_2:\omega_3=\sqrt{2}:\sqrt{2}:1$$

@apna_pdf

753. A wheel is rotating with an angular speed of 20 rad/s. It is stopped to rest by applying a constant torque in 4s. If the moment of inertia of the wheel about its axis is 0.20 kg-m^2, then the work done by the torque in two seconds will be

(a) 10 J (b) 20 J
(c) 30 J (d) 40 J

UP CPMT-2014

Ans. (c) : Given, $\omega_1 = 20$ rad/s, $\omega = 0$ at $t = 4$ s

So, angular retardation $(\alpha) = \frac{\omega - \omega_1}{t} = \frac{0-20}{4} = -5\,\text{rad/s}^2$

Now, angular speed after 2s,
From law of angular motion,

$$\omega_2 = \omega_1 + \alpha t$$
$$= 20 - 5 \times 2$$
$$= 10\,\text{rad/s}$$

From work energy theorem,
Work done by torque in 2s = Loss in Kinetic Energy

$$= \frac{1}{2}I(\omega_1^2 - \omega_2^2)$$
$$= \frac{1}{2} \times (0.20)\left[(20)^2 - (10)^2\right]$$
$$= \frac{1}{2} \times (0.20) \times (400 - 100)$$
$$= \frac{1}{2} \times (0.20) \times 300$$
$$= 30\,\text{J}$$

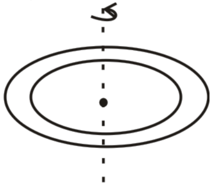
754. A disc of moment of inertia 'I_1' is rotating in horizontal plane about an axis passing through a centre and perpendicular to its plane with constant angular speed 'ω_1'. Another disc of moment of inertia 'I_2' having zero angular speed is placed coaxially on a rotating disc. Now both the discs are rotating with constant angular speed 'ω_2'. The energy lost by the initial rotating disc is

(a) $\frac{1}{2}\left[\frac{I_1 + I_2}{I_1 I_2}\right]\omega_1^2$ (b) $\frac{1}{2}\left[\frac{I_1 I_2}{I_1 - I_2}\right]\omega_1^2$

(c) $\frac{1}{2}\left[\frac{I_1 - I_2}{I_1 I_2}\right]\omega_1^2$ (d) $\frac{1}{2}\left[\frac{I_1 I_2}{I_1 + I_2}\right]\omega_1^2$

MHT-CET 2016

Ans. (d) : Given,
Angular velocity of 2nd disc $(\omega_1) = 0$



After placing 2nd disc on Ist disc moment inertia of the system $(I) = I_1 + I_2$

By the law of conservation of angular momentum

$$I_1\,\omega_1 + I_2 \times 0 = (I_1 + I_2)\,\omega_2$$

$$I_1\,\omega_1 = (I_1 + I_2)\,\omega_2$$

$$\omega_2 = \frac{I_1\,\omega_1}{I_1 + I_2} \qquad \ldots(i)$$

Kinetic energy (K.E) $= \frac{1}{2}I\omega^2$

So, kinetic energy initially,

$$(\text{K.E})_1 = \frac{1}{2}I_1\omega_1^2$$

Kinetic energy after placing 2nd disc on Ist disc

$$(\text{K.E})_2 = \frac{1}{2}(I_1 + I_2).\omega_2^2$$

Putting the value of ω_2 from (i), we get-

$$(\text{K.E})_2 = \frac{1}{2}(I_1 + I_2).\frac{I_1^2\omega_1^2}{(I_1 + I_2)^2}$$

$$(\text{K.E})_2 = \frac{1}{2}\frac{I_1^2\omega_1^2}{(I_1 + I_2)}$$

Loss in energy = (K.E)$_1$ – (K.E)$_2$

$$\Delta K = \frac{1}{2}I_1\omega_1^2 - \frac{1}{2}\frac{I_1^2\omega_1^2}{(I_1 + I_2)}$$

$$\Delta K = \frac{1}{2}I_1\omega_1^2\left[1 - \frac{I_1}{I_1 + I_2}\right]$$

$$\Delta K = \frac{1}{2}I_1\omega_1^2\left[\frac{I_2}{I_1 + I_2}\right]$$

$$\Delta K = \frac{1}{2}\left[\frac{I_1 I_2}{I_1 + I_2}\right]\omega_1^2$$

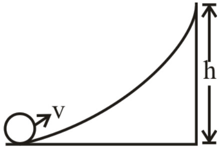
755. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is

(a) ring (b) solid sphere
(c) hollow sphere (d) disc

MHT-CET 2013

Ans. (d) : Given that,
Initial velocity = v

$$\text{Height}_{(\text{max})} = \frac{3v^2}{4g}$$



If any object rolling on the curved surface then the kinetic energy of object is changes into potential energy.

So, by the law of conservation of mechanical energy,
Kinetic energy + Rotational kinetic energy = Potential energy

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

@apna_pdf

$$\frac{1}{2}mv^2+\frac{1}{2}I\left(\frac{v}{r}\right)^2=mg\left(\frac{3v^2}{4g}\right) \qquad \left(\begin{array}{l}\because\ \omega=v/r\\ h=\dfrac{3v^2}{4g}\end{array}\right)$$

$$\frac{1}{2}I\left(\frac{v^2}{r^2}\right)=\frac{3mv^2}{4}-\frac{1}{2}mv^2$$

$$\frac{1}{2}I\left(\frac{v^2}{r^2}\right)=\frac{3mv^2-2mv^2}{4}$$

$$\frac{1}{2}I\frac{v^2}{r^2}=\frac{1}{4}mv^2$$

$$I=\frac{1}{2}mr^2$$

Hence, object is a disc.

756. The moment of inertia of two freely rotating bodies A and B are I_A and I_B, respectively. $I_A>I_B$ and their angular moment are equal. If K_A and K_B are their kinetic energies, then

(a) $K_A=K_B$ (b) $K_A\neq K_B$
(c) $K_A<K_B$ (d) $K_A=2K_B$

MHT-CET 2009

Ans. (c) : We know that,
The relation between kinetic energy, angular momentum, and moment of intia is

$$K=\frac{L^2}{2I}$$

The angular momentum is the same for both the bodies, we can write

Then, $K\propto\frac{1}{I}$

Kinetic Energy is inversely proportional to the moment of inertia.
If $I_A>I_B$
Then $K_A<K_B$

757. A disc of moment of inertia $\frac{9.8}{\pi^2}$ kg-m^2 is rotating at 600 rpm. If the frequency of rotation changes from 600 rpm to 300 rpm, then what is the work done ?

(a) 1467 J (b) 1452 J
(c) 1567 J (d) 1632 J

MHT-CET 2004

Ans. (a) : Using work energy theorem,
Work done = change in rotational kinetic energy

$$\text{Work done} = \Delta K\,E_{\text{rotational}}=\frac{1}{2}I\omega_i^2-\frac{1}{2}I\omega_f^2$$

$$\because \quad \omega_i=600\times\frac{2\pi}{60}=20\pi\ \text{rad/s}$$

Similarly $\omega_f=10\pi$ rad/s

$$I=\frac{9.8}{\pi^2}\text{kg-m}^2$$

$$\therefore \quad \text{Work Done}=\frac{1}{2}I\left[(20\pi)^2-(10\pi)^2\right]$$

$$=\frac{1}{2}\times\frac{9.8}{\pi^2}\times\left(300\pi^2\right)=1470\text{ J} \sqcup 1467\text{ J}$$

$$=1467\text{J}$$

758. A solid sphere of mass M and radius 2R rolls down an inclined plane of height h without slipping. The speed of its centre of mass when it reaches the bottom is

(a) $\sqrt{\frac{6}{7}gh}$ (b) $\sqrt{3gh}$
(c) $\sqrt{\frac{10}{7}gh}$ (d) $\sqrt{\frac{4}{3}gh}$

JIPMER-2016

Ans. (c): Potential energy of solid Cylinder of mass M at height (h) = Mgh
When the solid sphere rolls down on an inclined plane then it has both rotational and translational kinetic energy.

$$K=K_{\text{rot}}+K_{\text{trans}}$$

$$K=\frac{1}{2}I\omega^2+\frac{1}{2}MV^2 \qquad (V=R\omega)$$

$$=\frac{1}{2}\times\frac{2}{5}M(2R)^2\left(\frac{V}{2R}\right)^2+\frac{1}{2}MV^2 \qquad \left(\begin{array}{l}I=\dfrac{1}{2}MR^2\\ \text{for solid sphere}\end{array}\right)$$

$$=\frac{4}{5}\times MR^2\frac{V^2}{4R^2}+\frac{1}{2}MV^2$$

$$=\frac{1}{5}MV^2+\frac{1}{2}MV^2=\frac{7}{10}MV^2$$

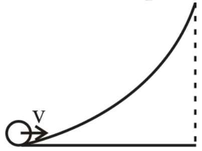
Now gain of kinetic energy = loss in potential energy

$$\frac{7}{10}MV^2=Mgh$$

$$V=\sqrt{\frac{10}{7}gh}$$

(g) Rolling Motion

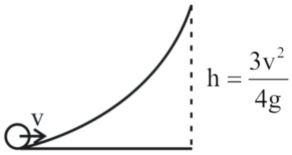
759. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is:



(a) ring (b) solid sphere
(c) hollow sphere (d) disc

Assam CEE-2017
Assam CEE- 2014
NEET-2013

Ans. (d):



@apna_pdf

From conservation of energy,

$$(K.E.)_t + (K.E.)_r = P.E.$$

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mg\left(\frac{3v^2}{4g}\right) \qquad \left(\because h = \frac{3v^2}{4g}\text{ ,given}\right)$$

$$\frac{1}{2}mv^2 + \frac{1}{2}I \times \frac{v^2}{r^2} = mg\left(\frac{3v^2}{4g}\right)$$

$$\frac{m}{2} + \frac{I}{2r^2} = \frac{3m}{4}$$

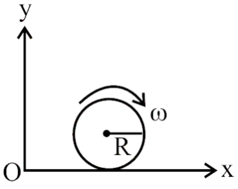
$$\frac{I}{2r^2} = \frac{3}{4}m - \frac{1}{2}m$$

$$\frac{I}{2r^2} = \frac{m}{4}$$

$$I = \frac{mr^2}{2}$$

Hence, the object must be disc.

760. A spherical shell of 1 kg mass and radius R is rolling with angular speed ω on horizontal plane (as shown in figure). The magnitude of angular momentum of the shell about the origin O is $\frac{a}{3}R^2\omega$. The value of a will be



(a) 2 (b) 3
(c) 5 (d) 4

JEE Main-29.06.2022, Shift-I

Ans. (c) : Given, Radius of spherical shell = R
Mass of spherical shell (m) = 1 kg

Moment of inertia of spherical shell (I) = $\frac{2}{3}mR^2$

Let, L_0 = Angular momentum of shell about O.
For rolling shell,

$$v = \omega R$$

So, $$L_0 = mvR + I\omega$$

$$= 1 \times \omega R \times R + \frac{2}{3} \times 1 \times R^2 \times \omega$$

$$= \omega R^2\left(1+\frac{2}{3}\right)$$

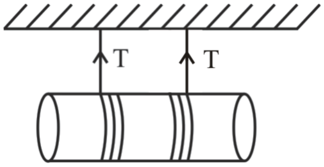
$$L_0 = \frac{5}{3}\omega R^2 \qquad \text{....(i)}$$

Comparing equation (i) with angular momentum of shell given by $L_0 = \frac{a}{3}\omega R^2$ we get,

$$\frac{a}{3} = \frac{5}{3}$$

$$a = 5$$

761. A solid cylinder length is suspended symmetrically through two massless strings, as shown in the figure. The distance from the initial rest position, the cylinder should by unbinding the strings to achieve a speed of 4 ms^{-1}, is ....cm.
(take g = 10 ms^{-2})



JEE Main-27.07.2022, Shift-II

Ans. (120) : Let the cylinder unbinded at distance h from the initial rest position
By using the law of conservation of energy.

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid cylinder, $I = \frac{1}{2}mR^2$

So, $$mgh = \frac{1}{2}mv^2 + \frac{1}{2} \times \frac{1}{2}mR^2 \times \omega^2$$

$$gh = \frac{1}{2}v^2 + \frac{1}{4}v^2 \qquad \{\because v = R\omega\}$$

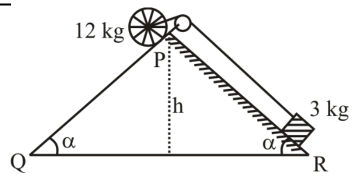
$$gh = \frac{3}{4}v^2$$

$$h = \frac{3}{4g}v^2$$

$$h = \frac{3}{4} \cdot \frac{(4)^2}{10} = 1.2\text{m}$$

h = 120 cm.

762. A rolling wheel of 12 kg is on an inclined plane at position P and connected to a mass of 3 kg through a string of fixed length and pulley as shown in figure. Consider PR as friction free surface.
The velocity of centre of mass of the wheel when it reaches at the bottom Q of the inclined plane PQ will be $\frac{1}{2}\sqrt{xgh}$ m/s. The value of x is ______.



JEE Main-27.06.2022, Shift-II

Ans. (3) : Given,
Mass of wheel (m_1) = 12 kg
Mass of object (m_2) = 3 kg
By law of conservation of energy
Net loss in P.E = Gain in K.E.

$$m_1gh - m_2gh = \frac{1}{2}m_1v^2 + \frac{1}{2}I\omega^2 + \frac{1}{2}m_2v^2$$

@apna_pdf

$$12gh - 3gh = \frac{1}{2}.3.v^2 + \frac{1}{2}.12r^2.\frac{v^2}{r^2} + \frac{1}{2}12v^2$$

$$\left\{\begin{matrix}\because I = mr^2 \\ \& \ \omega = \frac{v}{r}\end{matrix}\right\}$$

$$9gh = \frac{27}{2}v^2$$

$$v^2 = \frac{2}{3}gh$$

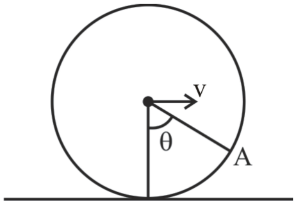
$$\Rightarrow v = \frac{1}{2}\sqrt{\frac{8}{3}gh} \qquad .....(i)$$

Comparing equation (i) with $v = \frac{1}{2}\sqrt{xgh}$ we get,

$$x = \frac{8}{3} = 2.66$$

$$\boxed{x \approx 3}$$

763. As shown in the figure a circular loop is rolling without slipping horizontally with a linear speed v. What is the speed of the point A

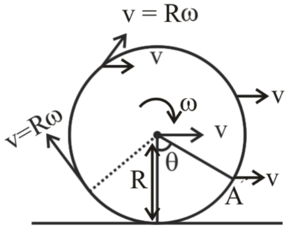


(a) $v\sin\theta$ (b) $v\cos\theta$

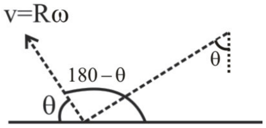
(c) $2v\cos(\theta/2)$ (d) $2v\sin(\theta/2)$

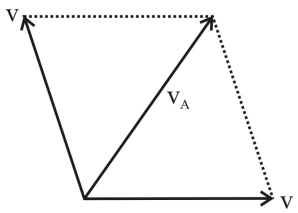
Assam CEE-2021

Ans. (d) :



at point A,





$$v_A = \sqrt{v^2 + v^2 + 2vv\cos(180-\theta)}$$

$$v_A = \sqrt{2v^2 + 2v^2(-\cos\theta)}$$

$$v_A = \sqrt{2v^2(1-\cos\theta)} \qquad \left\{\because 1-\cos\theta = 2\sin^2\frac{\theta}{2}\right\}$$

$$v_A = \sqrt{2v^2.\left(2\sin^2\frac{\theta}{2}\right)}$$

$$v_A = 2v\sin\frac{\theta}{2}$$

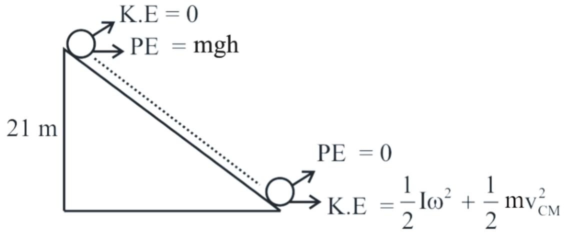
764. A solid sphere is rolling down an inclined plane of height 21 m without slipping. The maximum velocity with which it will reach the bottom of the plane is _________ ($g = 10m.s^{-2}$)

(a) 17 $m.s^{-1}$ (b) $10\sqrt{3}$ $m.s^{-1}$

(c) 10 $m.s^{-1}$ (d) $17\sqrt{3}$ $m.s^{-1}$

AP EAMCET-07.09.2021, Shift-I

Ans. (b) : Give, height (h) = 21m, g = 10m/sec^2



For solid sphere (I) = $\frac{2}{5}mR^2$

From the law of conservation of energy,

$$E_i = E_f$$

$$PE_i + KE_i = PE_f + KE_f$$

$$(mgh) + 0 = 0 + \frac{1}{2}I\omega^2 + \frac{1}{2}mv_{CM}^2 \qquad ...(i)$$

For pure rolling –

$$v_{CM} = \omega R$$

Moment of inertia of solid sphere, I = $\frac{2}{5}MR^2$ and

v = ωR

$$mgh = \frac{1}{2}\left(\frac{2}{5}mR^2\right)\left(\frac{v}{R}\right)^2 + \frac{1}{2}mv_{CM}^2$$

$$gh = \frac{v_{CM}^2}{5} + \frac{v_{CM}^2}{2}$$

$$gh = \left(\frac{1}{5}+\frac{1}{2}\right)v_{CM}^2$$

$$v_{CM} = \sqrt{\frac{10}{7}gh} = \sqrt{\frac{10}{7}\times 10\times 21}$$

$$v_{CM} = \sqrt{300}$$

$$v_{CM} = 10\sqrt{3}\,m/s$$

765. The kinetic energy of a rolling ring of mass 0.3 kg about an axis passing through its center of mass and perpendicular to its plane, if its center of mass is moving with a velocity of 8 $m.s^{-1}$ is –

@apna_pdf

(a) 11.2 J (b) 19.2 J
(c) 25 J (d) 32 J

AP EAMCET-06.09.2021, Shift-I

Ans. (b) : Given, mass of rolling ring (m) = 0.3 kg, velocity (v) = 8 m/s,

For rolling ring, moment of inertia-

$$I = mR^2$$

Total kinetic energy,

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mR^2\left(\frac{v^2}{R^2}\right)$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$K.E. = mv^2 = 0.3 \times (8)^2 = 19.2 \text{ J}$$

766. If rotational inertia parameter of a body rolling down a rough inclined plane (of inclination θ and height h) without slipping is given by $\beta = I_{cm}/MR^2$, then time taken by the body to reach the bottom of the inclined plane is given by _______.

(a) $t = \frac{1}{\sin\theta}\sqrt{\frac{(1+\beta)2h}{g}}$

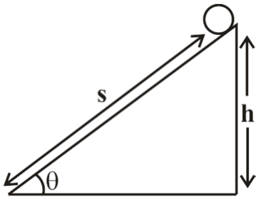
(b) $t = \frac{1}{\cos\theta}\sqrt{\frac{(1+\beta)2h}{g}}$

(c) $t = \frac{1}{\sin\theta}\sqrt{\frac{(1-\beta)2h}{g}}$

(d) $t = \frac{1}{\sin\theta}\sqrt{\frac{(1+\beta)h}{g}}$

AP EAMCET-23.08.2021, Shift-II

Ans. (a) :



Acceleration of the body rolling down the inclined plane is given by

torque due to rotation $\tau = I\alpha$

$$F.R = (MR^2 + I_{CM}\alpha)$$

$$F.R = \left(1 + \frac{I_{CM}}{MR^2}\right)MR^2\alpha$$

$$Mg\sin\theta.R = MR^2\alpha\left(1 + \frac{I_{CM}}{MR^2}\right)$$

$$g\sin\theta = R\alpha\left(1 + \frac{I_{CM}}{MR^2}\right)$$

$$g\sin\theta = a\left(1 + \frac{I_{CM}}{MR^2}\right) \qquad \left(\because \alpha = \frac{a}{R}\right)$$

$$a = \frac{g\sin\theta}{\left(1 + \frac{I_{CM}}{MR^2}\right)}$$

$$a = \frac{g\sin\theta}{1 + \frac{I_{cm}}{MR^2}}$$

$$a = \frac{g\sin\theta}{1+\beta} \qquad \left(\text{Given, } \beta = \frac{I_{cm}}{MR^2}\right)$$

Initial velocity of the body (u) = 0

Distance covered by the body

$$s = \frac{h}{\sin\theta}$$

Using $s = ut + \frac{1}{2}at^2$

$$\therefore \quad \frac{h}{\sin\theta} = 0 + \frac{g\sin\theta}{2(1+\beta)}t^2$$

$$t = \frac{1}{\sin\theta}\sqrt{\frac{2h(1+\beta)}{g}}$$

767. A small disc of mass 500 gm and radius 5 cm rolls down an inclined plane without slipping. Speed of its center of mass when it reaches the bottom of the incline plane depends on

(a) mass & radius
(b) mass & height of the incline
(c) height of the incline
(d) height of the incline and acceleration due to gravity

TS EAMCET 04.08.2021, Shift-I

Ans. (d) : Initial kinetic energy of the system is zero as the system is at rest initially.

Moment of inertia for a disc about its center,

$$I = \frac{1}{2}mR^2$$

As there no slipping, thus, $v = R\omega$ .....(i)

Using work energy theorem,

$$W = \Delta K.E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$\therefore \quad mgh = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{mR^2}{2}\times\frac{v^2}{R^2} \qquad [\text{For equation (i)}]$$

$$mgh = \frac{3}{4}mv^2$$

$$v = \sqrt{\frac{4}{3}gh}$$

$$\therefore \quad v \propto \sqrt{gh}$$

768. A rigid body of mass M and radius R rolls without slipping on an inclined plane of inclination θ under gravity. Match the type of body Column I with magnitude of the force of friction Column II.

@apna_pdf

Column I	Column II
(A) For ring	**(I)** $\frac{Mg\sin\theta}{2.5}$
(B) For solid sphere	**(II)** $\frac{Mg\sin\theta}{3}$
(C) For solid cylinder	**(III)** $\frac{Mg\sin\theta}{3.5}$
(D) For hollow spherical shell	**(IV)** $\frac{Mg\sin\theta}{2}$

	A	B	C	D
(a)	IV	III	II	I
(b)	I	II	III	IV
(c)	II	I	IV	III
(d)	II	IV	I	III

TS EAMCET 04.08.2021, Shift-I

Ans. (a) : We know that,

$$f = \frac{Mg\sin\theta}{\left(1+\frac{MR^2}{I}\right)}$$

For ring, $I = MR^2$

$$f = \frac{Mg\sin\theta}{2}$$

For hollow sphere,

$$f = \frac{Mg\sin\theta}{5/2} = \frac{Mg\sin\theta}{2.5}$$

For solid cylinder, $I = \frac{1}{2}MR^2$

$$f = \frac{Mg\sin\theta}{3}$$

For solid sphere, $I = \frac{2}{5}MR^2$

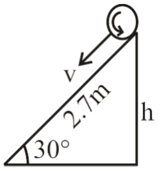
$$f = \frac{Mg\sin\theta}{3.5}$$

769. A solid cylinder rolls without slipping from top of an incline of length 2.7 m with angle of inclination 30°. What will be its speed when it reaches the bottom of the incline? [use $g = 10\ m/s^2$]

(a) 2 m/s
(b) $2\sqrt{2}\ m/s$
(c) 3 m/s
(d) $3\sqrt{2}\ m/s$

TS EAMCET (Medical) 09.08.2021, Shift-I

Ans. (d) :



$$\frac{h}{\sin\theta} = 2.7\ m$$

$$h = 2.7\times\sin 30° = 2.7\times\frac{1}{2}$$

$$h = 1.35m$$

From the law of conservation of energy,

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mg(1.35)$$

$$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2 = mg(1.35)$$

$(\because I = \frac{1}{2}mr^2$ for Solid cylinder)

For rolling, $v = r\omega \Rightarrow v^2 = r^2\omega^2$

So,

$$\frac{1}{2}mv^2 + \frac{1}{4}mv^2 = mg\,(1.35)$$

$$\frac{3}{4}v^2 = 10\times1.35$$

$$v^2 = \frac{10\times1.35\times4}{3} = 18$$

$$v = \sqrt{18}$$

$$v = 3\sqrt{2}\ m/s$$

770. If a ring rolls down from top to bottom of an inclined plane, it takes time t_1. If it slides, it takes time t_2. Then the ratio $\frac{t_2^2}{t_1^2}$ is

(a) 1/3
(b) 2/3
(c) 1/4
(d) 1/2
(e) 2/5

Kerala CEE 2020

Ans. (d) : While inclined plane-

For sliding, acceleration (a) = g sinθ

$$t_2 = \sqrt{\frac{2\ell}{g\sin\theta}} \quad \text{....(i)}$$

For rolling, acceleration (a) = $\frac{g\sin\theta}{2}$

$$t_1 = \sqrt{\frac{2\ell}{g\sin\theta}\times2} \quad \text{....(ii)}$$

Divide equation (i) by (ii), we get-

$$\frac{t_2}{t_1} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$

Square both side

$$\boxed{\frac{t_2^2}{t_1^2} = \frac{1}{2}}$$

@apna_pdf

771. A solid cylinder is released from rest from the top of an inclined plane of inclination 30° and length 60 cm. If the cylinder rolls without slipping, then the speed when it reaches the bottom is

(a) 1.5 m/s (b) 2.0 m/s

(c) 3.0 m/s (d) 6.0 m/s

TS-EAMCET.11.09.2020, Shift-2

Ans. (b): Given,

$\theta = 30^o$, $l = 60\text{cm} = 60 \times 10^{-2}\,\text{m}$

By work energy theorem,

$$mg(l\sin\theta) = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

$$mg(l\sin\theta) = \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2 \qquad (\because v = r\omega)$$

$$mg(l\sin\theta) = \left(\frac{1}{4} + \frac{1}{2}\right)mv^2$$

$$gl\sin\theta = \left(\frac{1+2}{4}\right)v^2$$

$$gl\sin\theta = \frac{3}{4}v^2$$

$$v^2 = \frac{4\,gl\sin\theta}{3}$$

$$v = \sqrt{\frac{4\,gl\sin\theta}{3}}$$

$$v = \sqrt{\frac{4 \times 9.8 \times 60 \times 10^{-2} \times \sin 30^o}{3}}$$

$v = 1.92$

$v \approx 2\text{ m/s}$

772. A solid sphere of mass 2 kg rolls on a smooth horizontal surface at 10 m/s. It then rolls up a smooth inclined plane of inclination 30° with the horizontal. The height attained by the sphere before it stops is [take $g = 10\text{ m/s}^2$]

(a) 70 cm (b) 701 cm

(c) 7.0 m (d) 70 m

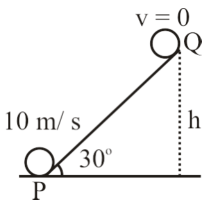
TS-EAMCET-11.09.2020, Shift-1

Ans. (c) : Given,

Mass of solid sphere = 2 kg

Velocity (v) = 10 m/s

Angle (θ) = 30°



If sphere is at point P, sphere has kinetic energy and rotational energy and when it is at point Q, it have only potential energy.

From law of conservation of energy,

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{2} \times \frac{2}{5}mr^2 \times \frac{v^2}{r^2} = mgh \qquad \left[\begin{aligned}&\therefore I = \frac{2}{5}mr^2\\ &\text{and } \omega = \frac{v}{r}\end{aligned}\right]$$

$$mv^2\left[\frac{1}{2} + \frac{1}{5}\right] = mgh$$

$$\frac{7v^2}{10} = gh$$

Put the value of v and g,

$$h = \frac{7 \times (10)^2}{10 \times 10}$$

$h = 7\text{m}$

773. A solid sphere and a solid cylinder, each of mass M and radius R are rolling with a linear speed on a flat surface without slipping. Let L_1 be magnitude of the angular momentum of the sphere with respect to a fixed point along the path of the sphere. Likewise L_2 be the magnitude of angular momentum of the cylinder with respect to the same fixed point along its path. The ratio $\frac{L_1}{L_2}$ is

(a) $\frac{14}{15}$ (b) $\frac{4}{5}$

(c) $\frac{2}{5}$ (d) $\frac{7}{15}$

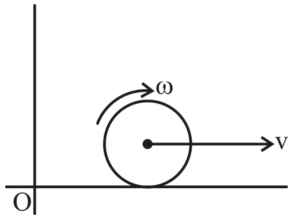
TS-EAMCET-10.09.2020, Shift-2

Ans. (a) : Given,

Mass of solid sphere and cylinder = M

Radius of solid sphere and cylinder = R

L_1 and L_2 are the magnitude of the angular momentum of the sphere and cylinder.



For linear motion $(L_1) = MvR$

$= M(R\omega) \times R \qquad (\therefore\ v = R\omega)$

$= MR^2 \times \omega$

For rotational motion $(L_2) = I\omega$

So,

Angular momentum about origin 'O' $(L_o) = L_1 + L_2$

$= MR^2\omega + I\omega$

$= \omega(MR^2 + I)$

@apna_pdf

We know,

Moment of inertia for solid sphere, $I = \frac{2}{5}MR^2$

And for solid cylinder, $I = \frac{1}{2}MR^2$

So, $(L_1)_{\text{about 'O'}} = \left(MR^2 + \frac{2}{5}MR^2\right)\omega = \frac{7}{5}MR^2\omega$

And $(L_2)_{\text{about 'O'}} = \left(MR^2 + \frac{1}{2}MR^2\right)\omega = \frac{3}{2}MR^2\omega$

So,

$$\frac{L_1}{L_2} = \frac{\frac{7}{5}MR^2\omega}{\frac{3}{2}MR^2\omega}$$

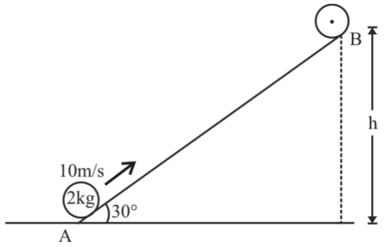
$$\frac{L_1}{L_2} = \frac{14}{15}$$

774. A solid sphere of mass 2 kg rolls on a smooth horizontal surface at 10 m/s and then rolls up a smooth inclined plane of inclination 30º with the horizontal. The maximum height reached by the sphere is ($g = 9.8$ m/s^2)

(a) 10 m
(b) 4.9 m
(c) 14.2 m
(d) 7.1 m

Manipal UGET -2020

Ans. (d) : Given –
Mass of solid sphere (m) = 2kg
Velocity (v) = 10 m/s



When the sphere is at point A, it possesses kinetic energy and rotational energy and when it is at point B it possesses only potential energy.
So from the law of conservation of energy –

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

Or $$\frac{1}{2}mv^2 + \frac{1}{2}mk^2 \times \frac{v^2}{R^2} = mgh$$

Or $$\frac{1}{2}mv^2\left[1 + \frac{k^2}{R^2}\right] = mgh$$

Or

$$\frac{1}{2}\times(10)^2\left[1 + \frac{2}{5}\right] = 9.8 \times h \quad \left\{\text{For solid sphere, } \frac{k^2}{R^2} = \frac{2}{5}\right\}$$

$$\frac{1}{2}\times 100 \times \frac{7}{5} = 9.8h \qquad \left[\begin{array}{l} 70 = 9.8h \\ h = \frac{700}{98} = 7.1 \end{array}\right]$$

$$h = 7.1 \text{ m}$$

775. A solid cylinder and a hollow cylinder both of the same mass and same external diameter are released from the same height at the same time on an inclined plane. Both roll down without slipping. Which one will reach the bottom first?

(a) Solid cylinder
(b) Both together
(c) One with higher density
(d) Hollow cylinder

BITSAT-2020

Ans. (a) : For a rolling body, acceleration is given by

$$a = \frac{g\sin\theta}{\left(1 + \frac{k^2}{R^2}\right)}$$

For solid sphere $I = \frac{2}{5}MR^2$

If radius of gyration is same for both cylinder then

$$Mk^2 = \frac{2}{5}MR^2$$

$$\frac{k^2}{R^2} = \frac{2}{5}$$

$$a_{\text{solid}} = \frac{5}{7}g\sin\theta = 0.71g\sin\theta$$

For hollow sphere $I = \frac{1}{2}MR^2$

$$Mk^2 = \frac{1}{2}MR^2 \Rightarrow \frac{k^2}{R^2} = \frac{1}{2}$$

$$a_{\text{hollow}} = \frac{2}{3}g\sin\theta = 0.66g\sin\theta$$

So,

$$a_{\text{solid}} > a_{\text{hollow}}$$

Hence, solid will reach the bottom first.

776. If mass, speed and radius of the circular path of the particle are increased by 100%, then the necessary force required to maintain the circular path will have to be increased by

(a) 100%
(b) 250%
(c) 300%
(d) 400%

AP EAMCET (17.09.2020) Shift-I

Ans. (c) : To the given data,
mass = m
radius = r
velocity = v
F = centripetal force
We know that, applying the force

$$F_c = \frac{mv^2}{r}$$

Now to the increment is 100% in mass velocity radius

m = m + m = 2m
v = v + v = 2v
r = r + r = 2r

@apna_pdf

Now hence, force is

$$F' = \frac{(m+m)(v+v)^2}{r+r}$$

$$F' = \frac{2m \times 4v^2}{2r} = 4\left(\frac{mv^2}{r}\right)$$

$$F' = F \times 4$$

Now the % change in force

$$= \frac{F'-F}{F} \times 100 = \frac{4F-F}{F} \times 100 = (4-1) \times 100$$

$$= 3 \times 100 = 300\ \%$$

777. The speed of a uniform solid sphere after rolling down from rest without slipping along a fixed inclined plane of vertical height h is

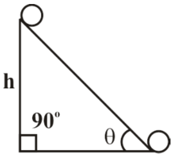
(a) $\sqrt{\frac{10gh}{7}}$ (b) $\sqrt{gh}$

(c) $\sqrt{\frac{6gh}{5}}$ (d) $\sqrt{\frac{4gh}{3}}$

AP EAMCET (17.09.2020) Shift-II

AIPMT-1992

Ans. (a) :



Using Work Energy Theorem,

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

For solid sphere, moment of inertia $I = \frac{2}{5}mr^2$ and $\omega = \frac{v}{r}$

$$mgh = \frac{1}{2} \times \frac{2}{5}mr^2 \times \left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2$$

$$mgh = \frac{1}{5}mv^2 + \frac{1}{2}mv^2$$

$$mgh = \frac{7}{10}mv^2$$

$$v^2 = \frac{10gh}{7}$$

$$v = \sqrt{\frac{10gh}{7}}$$

778. The centre of a wheel rolling on a plane surface move with a speed v_0. A particle on the rim of the wheel at the same level as the centre will be moving at a speed

(a) 0 (b) v_0

(c) $\sqrt{2}v_0$ (d) $2v_0$

AP EAMCET (21.09.2020) Shift-II

Ans. (c): Given that,

The velocity of the particle = v

The speed of the centre of wheel = v_0

Particle is on the rim of the wheel

For Pure rolling

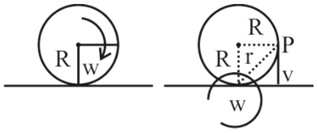
$v_0 = R\omega$ ....(i)

At P, $v = R\omega$

Therefore we have $v = \sqrt{(R^2 + R^2)}\omega$

$$v = \sqrt{2}R\omega$$

$$v = \sqrt{2}\ v_0 \qquad \{\text{ from (i) }\}$$



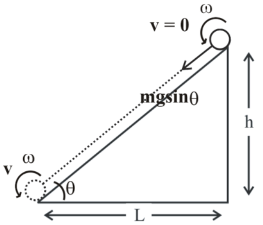
779. A solid cylinder of mass M and radius R rolls down an inclined plane of length L and height h, without slipping. Find the speed of its centre of mass when the cylinder reaches its bottom.

(a) $\sqrt{2gh}$ (b) $\sqrt{\frac{3gh}{4}}$

(c) $\sqrt{\frac{4gh}{3}}$ (d) $\sqrt{4gh}$

AP EAMCET (21.09.2020) Shift-I

Ans. (c) :



The given situation is shown in above figure when cylinder reaches at bottom, then its potential energy is converted into its rotational and linear kinetic energy of its centre of mass.

Hence,

By using work energy theorem,

$$Mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}Mv_{cm}^2$$

$$Mgh = \frac{1}{2} \times \frac{MR^2}{2} \times \left(\frac{v_{cm}}{R}\right)^2 + \frac{1}{2}Mv_{cm}^2$$

$$= \frac{Mv_{cm}^2}{4} + \frac{Mv_{cm}^2}{2} \qquad \left\{\because I = \frac{Mv^2}{2} \text{ and } \omega = \frac{v_{cm}}{R}\right\}$$

$$Mgh = \frac{3}{4}Mv_{cm}^2$$

$$v_{cm}^2 = \frac{4gh}{3}$$

$$v_{cm} = \sqrt{\frac{4gh}{3}}$$

@apna_pdf

780. A ring, a disc and a solid sphere have same mass and radius. All of them are rolled down on an inclined plane from same height, simultaneously. The body that will reach at the bottom, last, amongst is

(a) Ring (b) Disc
(c) Ring and disc (d) Solid sphere

MHT-CET 2019

Ans. (a) : Acceleration of body rolling down the inclined plane without sliding

$$a = \frac{g\sin\theta}{\left(1+\frac{I}{MR^2}\right)}$$

For ring, moment of inertia (I) = MR^2

$$\text{So,}\quad a_{ring} = \frac{g\sin\theta}{2}$$

$$a_{ring} = 0.5g\sin\theta$$

For disc, $I = \frac{1}{2}MR^2$

$$\text{So,}\quad a_{disc} = \frac{2}{3}g\sin\theta$$

$$a_{disc} = 0.67g\sin\theta$$

For sphere, $I = \frac{2}{5}MR^2$

$$a_{sphere} = \frac{5}{7}g\sin\theta$$

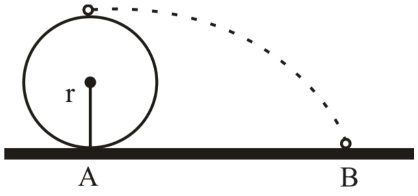
$$a_{sphere} = 0.71g\sin\theta$$

Therefore, order of their acceleration–

$a_{ring} < a_{disc} < a_{sphere}$

So, the acceleration of ring is least hence, the ring will reach at the bottom last.

781. A wheel of radius 'r' rolls without slipping with a speed 'v' on a horizontal road. When it is at a point 'A' on the road a small blob of the mud separates from wheel at the highest point and touches the point 'B' on the road as shown in the figure. Then AB is
(g- acceleration due to gravity)

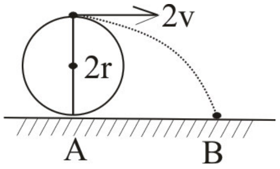


(a) $v\sqrt{gr}$ (b) $v\sqrt{\frac{r}{g}}$

(c) $4v\sqrt{\frac{r}{g}}$ (d) $2v\sqrt{\frac{r}{g}}$

AP EAMCET (Medical)-24.04.2019, Shift-I

Ans. (c) : Given,
The blob of mud would have a velocity '2v'
Initial speed u = 0, s = 2r
Now using the 2nd law of motion-



$$s = ut + \frac{1}{2}at^2$$

$$2r = 0 \times t + \frac{1}{2}at^2$$

$$2r = \frac{1}{2}gt^2$$

$$t^2 = \frac{4r}{g}$$

$$t = 2\sqrt{\frac{r}{g}}$$

Now,
Horizontal rotation

$$s = ut + \frac{1}{2}at^2 \qquad (\because u = 2v)$$

$$s = 2v\left(2\sqrt{\frac{r}{g}}\right) \qquad \left(\because \frac{1}{2}at^2 = 0\right)$$

$$\boxed{s = 4v\sqrt{\frac{r}{g}}}$$

782. A hollow sphere and a solid sphere, of equal mass and equal radii roll down without slipping on an inclined plane. If the torque experienced by the hollow sphere and solid sphere are τ_H and τ_S respectively, then

(a) $\tau_H < \tau_S$ (b) $\tau_H > \tau_S$
(c) $\tau_H = \tau_S$ (d) $\tau_H = 0$
(e) $\tau_S = 0$

Kerala CEE-2019

Ans. (b) : As we know moment of inertia of hollow sphere-

$$I_H = \frac{2}{3}MR^2$$

Moment of inertia of solid sphere-

$$I_S = \frac{2}{5}MR^2$$

$\therefore \quad I_H > I_S$

$\therefore$ Torque $= I\alpha$

Torque $= \tau_H > \tau_S$

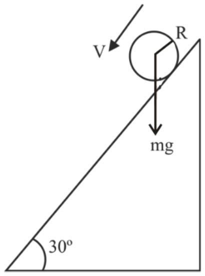
@apna_pdf

783. A ball of mass 1 kg and radius 0.5 m, starting from rest rolls down on a 30° inclined plane. The torque acting on the ball at the distance of the 7 m from the starting point is close to (Take acceleration due to gravity as 10 m/s^2)

(a) 0.25 N-m (b) 0.7 N-m
(c) 0.5 N-m (d) 0.4 N-m
(e) 1.4 N-m

Kerala CEE-2019

Ans. (b) : Given,
Mass (m) = 1kg, radius of ball (R) = 0.5m,
Angle of inclination $(\theta) = 30^\circ$



Acceleration of ball-

$$a = \frac{g\sin\theta}{1+\frac{I}{MR^2}}$$

$$a = \frac{10\times\sin 30^\circ}{1+\frac{\frac{2}{5}MR^2}{MR^2}} \quad \left(\because \quad I_{ball} = \frac{2}{5}MR^2\right)$$

$$= \frac{10\times\frac{1}{2}}{1+\frac{2}{5}} = \frac{5}{7/5} = \frac{25}{7}$$

$$\because \qquad \tau = I\alpha \qquad \left(\alpha = \frac{a}{R}\right)$$

Torque on the ball

$$\tau = \frac{2}{5}MR^2\left(\frac{25}{7}\right)\times\frac{1}{R}$$

$$= \frac{2}{5}\times 1\times 0.5\times\frac{25}{7} = \frac{5}{7}$$

$$\tau = 0.71\text{N-m}$$

784. A body rolls down an inclined plane. If its kinetic energy of rotational motion is 40% of its kinetic energy of translation, then the body is

(a) Ring (b) Solid sphere
(c) Solid dise (d) Cylinder

Assam CEE-2019

Ans. (b) : According to question,

$$(\text{K.E.})_{rotational} = 40\% \text{ of } (\text{K.E.})_{translation}$$

$$\frac{1}{2}I\omega^2 = 40\%\times\frac{1}{2}mv^2$$

$$I\omega^2 = 0.4mv^2$$

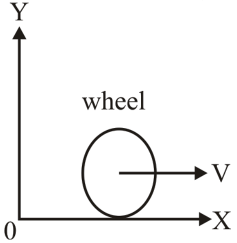
$$\frac{I\omega^2}{mv^2} = \frac{2}{5}$$

$$\frac{I\left(\frac{v^2}{R^2}\right)}{mv^2} = \frac{2}{5}$$

$$I = \frac{2}{5}mR^2$$

Hence, the object must be solid sphere.

785. A ring of mass 2kg and radius 4 m is in pure rolling on a horizontal plane as shown in figure. The angular momentum of ring about origin is (Given V_{CM} = 2 m/s)

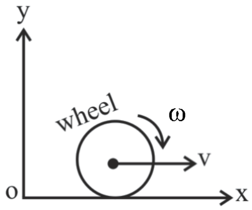


(a) 32 kgm^2/s (b) 24 kgm^2/s
(c) 16 kgm^2/s (d) 8 kgm^2/s

AIIMS-26.05.2019(M) Shift-1

Ans. (a) : Given that,

$$V_{CM} = 2m/s$$
$$m = 2kg$$
$$R = 4m$$
$$V_{CM} = R\,\omega$$



We know that,

$$L = I\omega + mV_{CM}R$$
$$L = mR^2\omega + m(R\omega)R$$
$$L = mR^2\omega + mR^2\omega$$
$$L = 2mR^2\omega$$

Now putting the value

$$L = 2\times(2)\times(4)^2\times\frac{V_{CM}}{R}$$

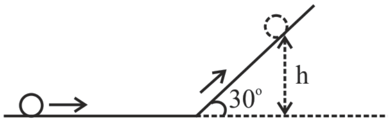
$$L = 4\times4\times4\times\frac{2}{4}$$

$$L = 32\,kg\,m^2/s$$

786. A solid spherical ball rolls on a horizontal surface at 10 m/s and continues to roll up on an inclined surface as shown in the figure. If the mass of the ball is 11 kg and frictional losses are negligible, the value of h where the ball stop and starts rolling down the inclination is

@apna_pdf

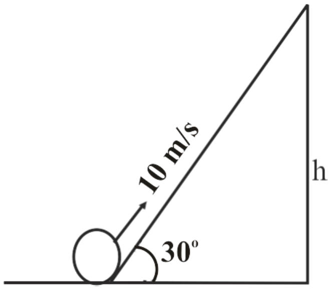
(Assume, g = 10 m/s)



(a) 8 m (b) 6 m
(c) 7 m (d) 10 m

TS-EAMCET-03.05.2019, Shift-2

Ans. (c) :



Given,
Velocity (v) = 10 m/s
Mass of ball (m) = 11 kg.
$g = 10 \text{ m/s}^2$

From conservation of energy,
Potential energy = Kinetic energy$_{\text{(Translational)}}$ + Kinetic energy$_{\text{(Rotational)}}$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2} \qquad \left[\begin{array}{l}\therefore I = \frac{2}{5}mr \\ \text{and } \omega = \frac{v}{r}\end{array}\right]$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$mgh = mv^2\left[\frac{1}{2}+\frac{1}{5}\right]$$

$$gh = v^2\left[\frac{7}{10}\right]$$

$$h = \frac{7v^2}{10g}$$

Putting the value of v and g,

$$h = \frac{7\times10\times10}{10\times10}$$

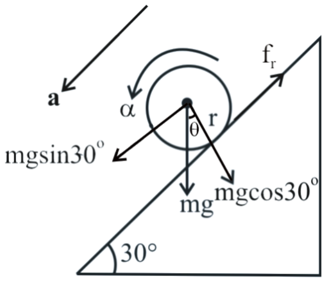
$$h = 7\text{m}$$

787. An inclined plane makes an angle 30° with horizontal. A solid sphere rolling down this inclined plane has a linear acceleration of

(a) $\frac{5g}{14}$ (b) $\frac{2g}{3}$
(c) $\frac{g}{3}$ (d) $\frac{5g}{7}$

Manipal UGET-2019

Ans. (a) :



From f.b.d., we have,

$$mg\sin30^\circ - f_r = ma \qquad .....(i)$$

And $\tau = f_r.r = I\times\alpha = \frac{2}{5}mr^2.\frac{a}{r}$

$$f_r = \frac{2}{5}ma$$

From equation (i), We get-

$$mg.\frac{1}{2} - \frac{2}{5}ma = ma$$

$$\frac{g}{2} = \frac{7}{5}a$$

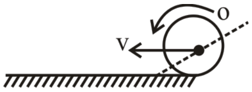
$$a = \frac{5}{14}g$$

788. A solid sphere of mass 5 kg rolls on a plane surface. Find its kinetic energy at an instant when its centre moves with speed 4 m/s.

(a) 56 J (b) 45 J
(c) 75 J (d) 105 J

TS-EAMCET-04.05.2019, Shift-1

Ans. (a) : Given that,s
m = 5 kg
v = 4 m/s



K.E (total) = K.E (translational) + K.E. (Rotational)

$$K.E_{\text{Total}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$K.E_{\text{Total}} = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{2}{5}mR^2\times\frac{v^2}{R^2} \qquad \left[\begin{array}{l}\therefore I = \frac{2}{5}mR^2 \\ \text{and } \omega = \frac{v}{R}\end{array}\right]$$

$$K.E_{\text{Total}} = \frac{1}{2}mv^2\left[1+\frac{2}{5}\right]$$

$$K.E_{\text{Total}} = \frac{1}{2}mv^2\times\frac{7}{5}$$

$$K.E_{\text{Total}} = \frac{1}{2}\times5\times4\times4\times\frac{7}{5}$$

$$K.E_{\text{Total}} = 56 \text{ J}$$

@apna_pdf

789. Three bodies, a ring, a solid disc and a solid sphere roll down the same inclined plane without slipping. The radii of the bodies are identical and they start from rest. If V_s, V_R and V_D are the speeds of the sphere, ring and disc, respectively when they reach the bottom, then the correct option is

(a) $V_s > V_R > V_D$ (b) $V_D > V_S > V_R$

(c) $V_R > V_D > V_S$ (d) $V_S > V_D > V_R$

TS-EAMCET-03.05.2019, Shift-1

Ans. (d) : Let the radii of ring, solid disc and solid sphere are identical be R.

Velocity of body when it reaches at the ground, $v = \sqrt{\dfrac{2gh}{\left(1+\dfrac{k^2}{R^2}\right)}}$

Where, h = height of inclined plane,

R = radius of body,

And k = radius of gyration

For a ring, $k^2 = R^2$

Speed of the ring, $v_R = \sqrt{\dfrac{2gh}{\left(1+\dfrac{R^2}{R^2}\right)}} = \sqrt{gh}$ ...(i)

For a solid sphere, $k^2 = \dfrac{2R^2}{5}$

Speed of the solid sphere, $v_s = \sqrt{\dfrac{2gh}{\left(1+\dfrac{2R^2}{5R^2}\right)}}$

$= \sqrt{\dfrac{10gh}{7}} = 1.19\sqrt{gh}$ ...(ii)

For a solid disc, $k^2 = \dfrac{R^2}{2}$

Speed of the solid disc, $v_D = \sqrt{\dfrac{2gh}{\left(1+\dfrac{R^2}{2R^2}\right)}}$

$= 1.15\sqrt{gh}$ ....(iii)

From equation (i), (ii) and (iii), it is clear that $V_S > V_D > V_R$.

790. A solid sphere rolls down without slipping on a smooth inclined plane of inclination $\sin^{-1}$ (0.42). If the acceleration due to gravity is 10 ms^{-2}, the acceleration of the rolling sphere is

(a) 1 ms^{-2} (b) 2 ms^{-2}

(c) 3 ms^{-2} (d) 4 ms^{-2}

AP EAMCET (22.04.2019) Shift-I

Ans. (c) : Given,

Inclination of inclined plane, $\theta = \sin^{-1}$ (0.42)

$\Rightarrow \sin\theta = 0.42$

Acceleration due to gravity (g) = 10m/sec^2

We know that,

$$a = \frac{g\sin\theta}{\left(1+\dfrac{I}{MR^2}\right)}$$

Where I = moment of inertia

R = radius of sphere

M = mass of sphere

$I = \dfrac{2}{5}MR^2$ {for solid sphere}

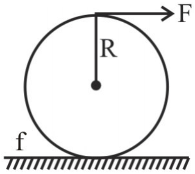
$$a = \frac{10\times0.42}{\left(1+\dfrac{2/5MR^2}{MR^2}\right)}$$

$$a = \frac{4.2}{\left(1+\dfrac{2}{5}\right)} = 4.2\times\frac{5}{7} = 0.6\times5$$

$a = 3.0$m/sec^2

791. A tangential force F acts at the top of a thin spherical shell of mass m and radius R. The acceleration of the shell if it rolls without slipping is

(f = rolling friction)

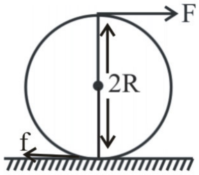


(a) $\dfrac{5F}{6m}$ (b) $\dfrac{6F}{5m}$

(c) $\dfrac{3F}{2m}$ (d) $\dfrac{F}{6m}$

AP EAMCET (20.04.2019) Shift-II

Ans. (b) :



Torque due to the force F on a thin spherical shell

$\tau = r \times F$

$= 2R\,F\sin90° = 2RF$ [$\because \sin90° = 1$]

$\because$ Angular acceleration,

$\alpha = \dfrac{\tau}{I}$ ...(i)

Where, I is moment of inertia of a thin spherical shell.

From parallel axis's theorem, moment of inertia of spherical shell,

$I = I_{cm} + mr^2$

or $I = \dfrac{2}{3}mR^2 + mR^2$ $(\because r = R)$

@apna_pdf

From Eq^n. (i), we get

$$\alpha = \frac{2RF}{\frac{2}{3}mR^2 + mR^2}$$

$$= \left(\frac{6}{5}\right)\frac{F}{Rm}$$

Hence, the tangential acceleration, $a_t = R\alpha$

or $\quad a_t = \left(\frac{6}{5}\right)\frac{F}{Rm} \times R = \frac{6}{5}\frac{F}{m}$

792. A solid sphere is in rolling motion. In rolling motion, a body possesses translational kinetic energy (K_t) as well as rotational kinetic energy (K_r) simultaneously. The ratio $K_t : (K_t + K_r)$ for the sphere is

(a) 10: 7 (b) 5: 7

(c) 7: 10 (d) 2: 5

NEET- 2018
AIPMT-1991

Ans. (b) : We know that,

Translational kinetic energy $K_t = \frac{1}{2}mv^2$ .....(i)

And, in rolling motion,

$$K_t + K_r = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\frac{v^2}{r^2} \qquad \left\{\begin{array}{l}\because I = \frac{2}{5}mr^2 \\ \& \ \omega = v/r\end{array}\right\}$$

$$K_t + K_r = \frac{7}{10}mv^2 \qquad \ldots\ldots \text{(ii)}$$

Dividing eq. (i) by (ii) we get,

$$\frac{K_t}{K_t + K_r} = \frac{\frac{1}{2}mv^2}{\frac{7}{10}mv^2} = \frac{10}{14} = \frac{5}{7}$$

Hence, required ratio,

$$K_t : (K_t + K_r) = 5:7$$

793. The times taken by a solid sphere, a solid cylinder a thin-walled hollow sphere and a thin-walled hollow cylinder all having the same mass to roll down an inclined plane when released at the top are denoted as t_{ss}, t_{sc}, t_{hs}, and t_{hc} respectively. The following is true with regard to the roll down times.

(a) $t_{hc} = t_{hs} > t_{sc} > t_{ss}$ (b) $t_{sc} > t_{hc} > t_{hs} > t_{ss}$

(c) $t_{ss} > t_{sc} > t_{hs} = t_{hc}$ (d) $t_{ss} = t_{sc} > t_{hs} = t_{hc}$

TS EAMCET 03.05.2018, Shift-I

Ans. (b) : We have, acceleration of body rolling down a inclined plane,

$$a = \frac{g\sin\theta}{1+k} \Rightarrow a \propto \frac{1}{k} \qquad \left(k = \frac{K^2}{R^2}\right) \qquad \ldots\text{(i)}$$

Now, radius of gyration,

For solid sphere, $k_{ss} = \frac{2}{5}$

For solid cylinder, $k_{sc} = \frac{1}{2}$

For hollow sphere, $k_{hs} = \frac{2}{3}$

For hollow cylinder, $k_{hc} = 1$

Now, from equation (i), it is visualized that,

$$a_{ss} > a_{sc} > a_{hs} > a_{hc}$$

Since,

$$s = ut + \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2s}{a}} \qquad \{\because u = 0\}$$

$$\Rightarrow \quad t \propto \frac{1}{\sqrt{a}}$$

Thus, roll down times of the bodies,

$$t_{ss} < t_{sc} < t_{hs} < t_{hc}$$

as options, $\quad t_{sc} > t_{hc} > t_{hs} > t_{ss}$

794. A solid cylinder rolls down from an inclined plane of height h. What is the velocity of the cylinder when it reaches at bottom of the plane?

(a) $\sqrt{\frac{2gh}{3}}$ (b) $\sqrt{2gh}$

(c) $\sqrt{\frac{4gh}{3}}$ (d) $\sqrt{\frac{3gh}{2}}$

BCECE-2018

Ans. (c) : Let M and R be the mass and radius of the solid cylinder respectively.

According to conservation of mechanical energy,

$$(K.E.)_T = (K.E.)_R + (R.E.)_T$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mR^2\right)\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mR^2\left(\frac{v}{R}\right)^2 \qquad \left(\because \ \omega = \frac{v}{R}\right)$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$mgh = \frac{3}{4}mv^2$$

$$v^2 = \frac{4}{3}gh$$

$$v = \sqrt{\frac{4gh}{3}}$$

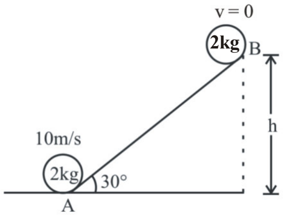
795. A solid sphere of mass 2 kg rolls on a smooth horizontal surface at 10 m/s. It then rolls up a smooth inclined plane of inclination 30° with the horizontal. The height attained by the sphere before it stops is

@apna_pdf

(a) 700 cm (b) 701 cm
(c) 7.1 m (d) None of these

AIIMS-27.05.2018(M)
UPSEE - 2008

Ans. (c) : Given,
Mass of solid sphere (m) = 2 kg
Velocity (v) = 10 m/s



Let the sphere attained a height h before it stops. When the sphere is at point A, it possesses kinetic energy and rotational kinetic energy and when it is at point B, it possesses only potential energy.
From law of conservation of energy,

$$\frac{1}{2}mv^2+\frac{1}{2}I\omega^2=mgh$$

$$\frac{1}{2}mv^2+\frac{1}{2}mk^2\times\frac{v^2}{R^2}=mgh \qquad \left\{\begin{array}{l}\therefore I=mk^2\\ \text{and } \omega^2=\dfrac{v^2}{R^2}\end{array}\right\}$$

$$\frac{1}{2}mv^2\left[1+\frac{k^2}{R^2}\right]=mgh$$

Putting the value in above equation,

$$\frac{1}{2}\times(10)^2\left[1+\frac{2}{5}\right]=9.8\times h \qquad \left[\begin{array}{c}\text{for solid sphere,}\\ \dfrac{k^2}{R^2}=\dfrac{2}{5}\end{array}\right]$$

$$\frac{1}{2}\times100\times\frac{7}{5}=9.8h$$

$$h=7.1\text{m}$$

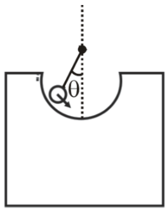
796. Assertion: When a sphere is rolls on a horizontal table it slows down and eventually stops.
Reason: When the sphere rolls on the table, both the sphere and the surface deform near the contact. As a result, the normal force does not pass through the centre and provide an angular deceleration.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

AIIMS-26.05.2018(E)

Ans. (b) : When a sphere rolls on the table it slows down and eventually stop because in this case, normal force acting at every point is different which provides necessary torque about centre of mass to cause angular deceleration.
Hence, both statement is correct but reason is not correct explanation of statement.

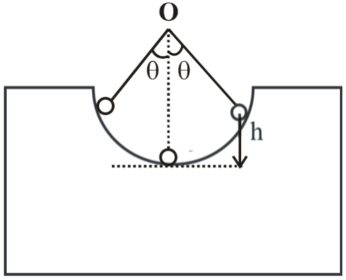
797. A solid sphere is rolling without slipping on a semi-circular track of radius 10 m as shown in the figure. The radius of solid sphere is much smaller than the radius of semi-circular track. At the lowest point, it has a velocity 10 m/s. To what maximum angle θ from the vertical will the sphere travel before it comes back down? Neglect the rolling friction between the sphere and the track.
(Take, g = 10 m/s^2)



(a) $\sin^{-1}\left(\frac{3}{5}\right)$ (b) $\sin^{-1}\left(\frac{3}{7}\right)$
(c) $\cos^{-1}\left(\frac{3}{10}\right)$ (d) $\cos^{-1}\left(\frac{1}{3}\right)$

TS-EAMCET-05.05.2018, Shift-2

Ans. (c) : Given,
Radius of semi - circular track (R) = 10 m
Velocity (v) = 10 m/s
Angle (θ) = ?
g = 10 m/s^2
Neglect the rolling friction between sphere and track



If sphere is rolling without slipping on the track, then energy is conserved.
So,
Mechanical energy of ball at bottom = Mechanical energy of ball at top

$$mgr+\frac{1}{2}mv^2+\frac{1}{2}I\omega^2=mgh$$

$$mgr+\frac{1}{2}mv^2+\frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2}=mgh \left[\begin{array}{l}\therefore I=\dfrac{2}{5}mr^2\\ \text{and } \omega=\dfrac{v}{r}\end{array}\right]$$

$$\frac{1}{2}mv^2+\frac{1}{5}mv^2=(mgh-mgr)$$

$$mv^2\left[\frac{1}{2}+\frac{1}{5}\right]=mg(h-r)$$

$$\frac{7v^2}{10}=g(h-r)$$

@apna_pdf

When r is neglected,

$$h = \frac{7v^2}{10g} \quad \text{....(i)}$$

Also, $h = R(1-\cos\theta)$ ....(ii)

On comparing equation (i) and (ii), we get-

$$\frac{7v^2}{10g} = R(1-\cos\theta)$$

Putting the value in above equation,

$$\frac{7\times10^2}{10\times10} = 10(1-\cos\theta)$$

$$\cos\theta = \frac{3}{10}$$

$$\theta = \cos^{-1}\left(\frac{3}{10}\right)$$

798. A hoop rolls down an inclined plane. The fraction of its total kinetic energy that is associated with rotational motions is

(a) 1 : 2 (b) 1 : 3

(c) 1 : 4 (d) 2 : 3

BITSAT-2018

Ans. (a) : We know that,

$$K.E(\text{total}) = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

Also the moment of inertia about the fix axis through its center of rotation is given as;

$$I = \frac{1}{2}mR^2$$

Hence,

$$(K.E.)_T = \frac{1}{4}mR^2\omega^2 + \frac{1}{2}mv^2$$

From the above formula, the rotational kinetic energy is given by:

$$(K.E)_r = \frac{1}{4}mR^2\omega^2$$

Also, the translational kinetic energy is given as:

$$(K.E)_t = \frac{1}{2}mv^2$$

$$\frac{(K.E)_r}{(K.E)_t} = \frac{\frac{1}{4}mR^2\omega^2}{\frac{1}{2}mv^2}$$

$$\frac{(K.E)_r}{(K.E)_t} = \frac{\frac{1}{4}R^2\omega^2}{\frac{1}{2}(R\omega)^2} \quad (\because v = R\omega)$$

$$\frac{(K.E)_r}{(K.E)_t} = \frac{1}{2}$$

Hence, $K.E_{\text{rotational}} : K.E_{\text{translational}} = 1:2$

799. A solid sphere and a ring of same radius roll down an inclined plane without slipping. Both start from rest from the top of the inclined plane. If the sphere and the ring reach the bottom of the inclined plane with velocities v_s and v_r respectively, then $\frac{v_r^2}{v_s^2}$ is

(a) 0.2 (b) 0.5

(c) 0.7 (d) 0.9

AP EAMCET (22.04.2018) Shift-II

Ans. (c) : Applying Work-energy theorem, we have

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

where moment of inertia, $I = mk^2$ and $\omega = \frac{v}{R}$

$$mgh = \frac{1}{2}mk^2\left(\frac{v}{R}\right)^2 + \frac{1}{2}mv^2$$

$$mgh = \frac{1}{2}mv^2\left(1+\frac{k^2}{R^2}\right)$$

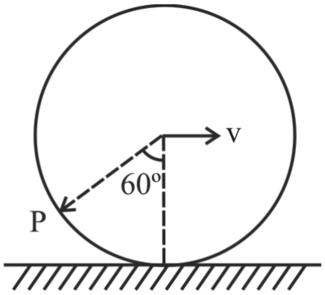
$$v^2 = \frac{2gh}{\left(1+\frac{k^2}{R^2}\right)}$$

Now, for ring $\frac{k^2}{R^2} = 1$ and for sphere, $\frac{k^2}{R^2} = \frac{2}{5}$

$$\therefore \quad \frac{v_r^2}{v_s^2} = \left(\frac{1+\frac{2}{5}}{1+1}\right)$$

$$\frac{v_r^2}{v_s^2} = \frac{7}{5}\times\frac{1}{2} = 0.7$$

800. A hoop rolls on a horizontal ground without slipping with a linear speed 10 ms^{-1}. Speed of a particle at a point P on the circumference of the hoop as shown in the figure is



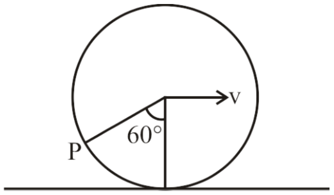
(a) 10 ms^{-1} (b) 5 ms^{-1}

(c) 20 ms^{-1} (d) $10\sqrt{2}$ ms^{-1}

AP EAMCET-24.04.2017, Shift-II

@apna_pdf

Ans. (a) : Given that,
Speed (v) = 10 m/s
$\theta = 60°$



We know that, speed of particle at point P is-

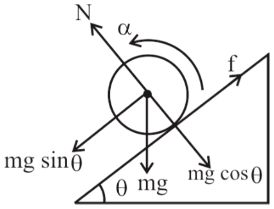
$$v_p = 2v.\sin\left(\frac{\theta}{2}\right)$$
$$= 2\times10\sin\frac{60°}{2}$$
$$= 20\times\sin30°$$
$$= 20\times\frac{1}{2}$$
$$v_p = 10\text{ m/s}$$

801. A cylinder rolls up an inclined plane, reaches some height and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are

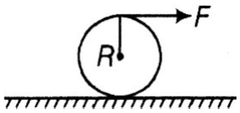
(a) up the incline while ascending and down the incline while descending.
(b) up the incline while ascending as well as descending.
(c) down the incline while ascending and up the incline while descending.
(d) down the incline while ascending as well as descending.

JIPMER-2017

Ans. (b) : The direction of the frictional force will be up the inclined plane in both the motions. The friction acts opposite to the relative motion of the point of contact on ground. In both cases, the force acting on the point of cylinder in contact with the plane is mg sinθ. As there is pure rolling, the velocity and acceleration of the point of contact must be zero, so friction acts upwards along the inclined plane in both the motions (ascending and descending).



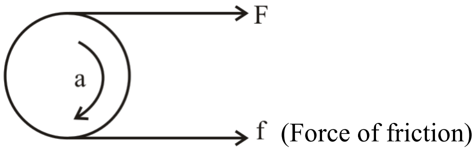
802. A tangential force F acts at the top of a thin spherical shell of mass 'm' and radius R. The acceleration of the shell, if it rolls without slipping is–



(a) $\frac{5F}{6m}$ (b) $\frac{6F}{5m}$
(c) $\frac{7F}{2F}$ (d) $\frac{2m}{7F}$

BCECE-2017

Ans. (b) : Let f be the force of friction between the shell and the horizontal surface



For translational motion from figure

$$F + f = ma \qquad .....(i)$$

For rotational motion, net torque

$$F\times R - f\times R = I\alpha$$
$$[a = R\alpha]$$
$$\Rightarrow \quad F - f = I\frac{a}{R^2} \qquad ......(ii)$$

On adding equation (i) and (ii) we get,

$$2F = \left(m + \frac{I}{R^2}\right)a$$

Substituting $I_{shell} = \frac{2}{3}mR^2$ for spherical shell, in the above equation

$$2F = \left(m + \frac{2}{3}m\right)a$$
$$F = \frac{5}{6}ma$$
$$\therefore \quad a = \frac{6F}{5m}$$

803. A body rolls down an inclined plane. If its kinetic energy of rotation is 40 % of its kinetic energy of translation motion, then the body is

(a) Hollow cylinder (b) Ring
(c) Solid disc (d) Solid sphere
(e) Hollow sphere

Kerala CEE 2005
Kerala CEE - 2015

Ans. (d) : Given, According to question,

$$(K.E.)_{rotation} = 40\%\ (K.E.)_{translation}$$
$$\frac{1}{2}I\omega^2 = \frac{40}{100}\times\frac{1}{2}mv^2$$
$$\because \quad v = r\omega, \quad \omega = v/r$$
$$\frac{1}{2}mk^2\left(\frac{v^2}{r^2}\right) = 0.4\times\frac{1}{2}mv^2$$
$$\frac{k^2}{r^2} = \frac{2}{5}$$
$$k^2 = \frac{2}{5}r^2$$

@apna_pdf

$$I = mk^2 = \frac{2}{5}mr^2$$

As we know that,

The moment of inertia of a solid sphere $(I) = \frac{2}{5}mr^2$

So, the body is a solid sphere.

804. The total energy of a solid sphere of mass 300 g which rolls without slipping with a constant velocity of 5 ms^{-1} along a straight line is

(a) 5.25 J
(b) 3.25 J
(c) 0.25 J
(d) 1.25 J
(e) 0.625 J

Kerala CEE- 2014

Ans. (a) : Given that,

Mass of solid sphere (m) = 300g = 300× 10^{-3}kg

constant velocity (v) = 5 ms^{-1}

We know that,

$$\text{kinetic energy (K.E.)} = \frac{1}{2}I\omega^2$$

For solid sphere moment of inertia $I = \frac{2}{5}mr^2$

$$\text{K.E.} = \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2 \text{ ....(i)}$$

Total kinetic energy = $(\text{K.E.})_{\text{rotation}} + (\text{K.E.})_{\text{translational}}$

$$(\text{K.E.})_{\text{total}} = \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2 + \frac{1}{2}mr^2\omega^2$$

$$(\text{K.E.})_{\text{total}} = \frac{1}{5}mr^2\omega^2 + \frac{1}{2}mr^2\omega^2$$

$$(\text{K.E.})_{\text{total}} = \frac{7}{10}mr^2\omega^2$$

$$(\text{K.E.})_{\text{total}} = \frac{7}{10}mv^2 \qquad (\because v = r\omega)$$

$$(\text{K.E.})_{\text{total}} = \frac{7}{10}\times 300\times 10^{-3}\times 5\times 5$$

$$(\text{K.E.})_{\text{total}} = 5.25\text{J}$$

805. A sphere of mass m and radius r rolls on a horizontal plane without slipping with the speed u. Now, if it rolls up vertically, then maximum height it would be attain will be

(a) $\frac{3u^2}{4g}$
(b) $\frac{5u^2}{2g}$
(c) $\frac{7u^2}{10g}$
(d) $\frac{u^2}{2g}$
(e) $\frac{11u^2}{9g}$

Kerala CEE 2007

Ans. (c) : Given that,

Mass of sphere = m

Radius of sphere = r

Speed = u

The rolling sphere has both rotational and translational energy

$$\therefore \quad \text{K.E.} = \frac{1}{2}mu^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of solid sphere $(I) = \frac{2}{5}mr^2$

$$\text{K.E.} = \frac{1}{2}mu^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2$$

$$\text{K.E.} = \frac{1}{2}mu^2 + \frac{1}{5}mu^2 \qquad \{\because u = r\omega\}$$

$$\text{K.E} = \frac{5mu^2 + 2mu^2}{10}$$

$$\text{K.E.} = \frac{7}{10}mu^2$$

From conservation of energy principle

K.E. = potential energy (P.E.)

$$\frac{7}{10}mu^2 = mgh$$

$$h = \frac{7u^2}{10g}$$

806. A solid sphere is rolling without slipping on a horizontal surface. The ratio of its rotational kinetic energy to its translational kinetic energy is

(a) 2/9
(b) 2/7
(c) 2/5
(d) 7/2

UPSEE - 2008

Ans. (c) : Given that,

Where m = mass of the body

v = velocity of the body

I = moment of inertia

ω = Angular velocity

The Rotational kinetic energy,

$$(\text{K.E.})_{\text{rotational}} = \frac{1}{2}I\omega^2$$

Where, I = Moment of inertia

ω = angular velocity

For Solid sphere moment of inertia $(I) = \frac{2}{5}mr^2$

$$\omega = \frac{v}{r} \quad \text{or} \quad \omega^2 = \frac{v^2}{r^2}$$

$$\therefore \quad (\text{K.E.})_{\text{rotational}} = \frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2}$$

$$(\text{K.E.})_{\text{rotational}} = \frac{1}{5}mv^2 \qquad \text{....(i)}$$

The kinetic energy of the solid sphere

$$(\text{K.E.})_{\text{translational}} = \frac{1}{2}mv^2 \qquad \text{....(ii)}$$

From equation (i) & (ii) we get,

$$\frac{(\text{K.E.})_{\text{rotational}}}{(\text{K.E.})_{\text{translational}}} = \frac{1/5mv^2}{1/2mv^2} = \frac{2}{5}$$

$$\frac{(\text{K.E.})_{\text{rotational}}}{(\text{K.E.})_{\text{translational}}} = \frac{2}{5}$$

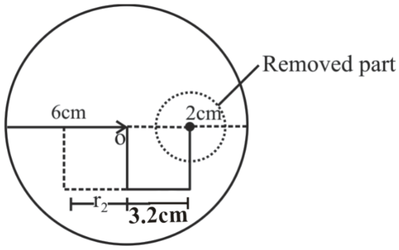
@apna_pdf

807. A small disc of radius 2cm is cut from a disc of radius 6cm. If the distance between their centre is 3.2cm, what is the shift in the centre of mass of the disc?

(a) 0.4 cm (b) 2.4 cm
(c) 1.8 cm (d) 1.2 cm

UPSEE - 2006

Ans. (a) :



Let, to the m = mass per unit area

m_1= Mass of removed disc = $(2)^2\pi m = 4\pi m$

m = Mass of disc = $\pi R^2 m = \pi\,(6)^2 m = 36\pi m$

m_2= Mass of remaining portion = $m - m_1$

$= 36\,\pi m - 4\pi m$

$= 32\,\pi m$

Center of mass of disc at origin

Centre of mass of removed disc = r_1 = 3.2 cm (given)

Centre of mass of remaining disc = r_2

Hence,

$$m \times 0 = m_1 r_1 + m_2 r_2$$

$$0 = m_1 r_1 + m_2 r_2$$

$$r_2 = \frac{-m_1 r_1}{m_2} = \frac{-4\pi m \times 3.2}{32\pi m}$$

$r_2 = -0.4$ cm = 0.4 cm

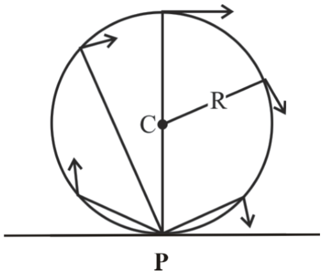
$-v_e$ sign indicate the shift from the center in opposite side.

808. A circular disc of radius R rolls without slipping along the horizontal surface with constant velocity v_0. We consider a point P on the surface of the disc. Then the acceleration of the point P is :

(a) Constant in magnitude as well as direction
(b) Constant in direction
(c) Constant in magnitude
(d) Constant

UPSEE - 2005

Ans. (a): The circular disc of radius R rolls without slipping along the horizontal surface with constant velocity. Its centre of mass is C and P is the point where disc is in contact with the surface at any instant. At this instant, each particle of disc is moving at right angle to the line which joins the particle to point P with velocity proportional to distance. So, the combined translational and rotational motion is equal to pure rotation and disc moves constant in magnitude as well as in direction. Therefore, the acceleration of point P on the surface of disc is also constant in magnitude as well as in direction.



809. A body is rolling down an inclined plane. Its translational and rotational kinetic energies are equal. The body is a :

(a) Solid sphere (b) Hollow sphere
(c) Solid cylinder (d) Hollow cylinder

UPSEE - 2004

Ans. (d) : The body is rolling down an inclined plane, then its translational and rotational kinetic energies both are equal.

Rotational kinetic energy $(K_R) = \frac{1}{2} I\omega^2$

Where, moment of inertia = I

Angular velocity = ω

Translational kinetic energy $(K_T) = \frac{1}{2} mv^2$

$$K_T = \frac{1}{2} m(r\omega)^2 \quad ....(i) \qquad (\because v = r\omega)$$

Solid sphere - moment of inertia of solid sphere

$$I = \frac{2}{5} mr^2$$

$$\therefore \quad K_R = \frac{1}{2} I\omega^2$$

$$K_R = \frac{1}{2}.\frac{2}{5} mr^2.\omega^2 = \frac{1}{5} mr^2\omega^2$$

So,

$K_R \neq K_T$ ....From eqn. (i)

Solid cylinder - moment of inertia of solid cylinder

$$I = \frac{1}{2} mr^2$$

$$K_R = \frac{1}{2}\left(\frac{1}{2} mr^2\right)\omega^2$$

$$K_R = \frac{1}{4} mr^2\omega^2$$

$K_R \neq K_T$ ....From eqn. (i)

Hollow cylinder- moment of inertia of hollow cylinder is

$$I = mr^2$$

$$\therefore \quad K_R = \frac{1}{2} I\omega^2$$

$$K_R = \frac{1}{2} mr^2\omega^2$$

So,

$K_R = K_T$

So, option (d) is correct answer.

@apna_pdf

810. Two uniform solid spheres having unequal masses and unequal radii are released from rest from the same height on a rough incline. If the spheres roll without slipping,

(a) the heavier sphere reaches the bottom first
(b) the bigger sphere reaches the bottom first
(c) the two spheres reach the bottom together
(d) the information given is not sufficient to tell which sphere will reach the bottom first

BITSAT-2007

Ans. (c) : For solid sphere-

$$a=\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$$

$$\frac{K^2}{R^2}=\frac{2}{5} \qquad \text{(Where K is radius of gyration)}$$

So acceleration is not affected in this case because it independent of mass. So, both sphere reach the bottom together.

811. One solid sphere and disc of same radius are falling along an inclined plane without slipping. One reaches earlier than the other due to

(a) different radius of gyration
(b) different sizes
(c) different friction
(d) different moment of inertia

BITSAT-2008

Ans. (a) : (i) For solid sphere, the moment of inertia about the diameter is $I_s=\frac{2}{5}MR^2$

Now I = MK^2 for anybody, where K is radius of gyration of that body.

So $MK^2=\frac{2}{5}MR^2 \Rightarrow K=R\sqrt{2/5}$ .....(i)

(ii) The moment of inertia of disc about an axis passing through its centre & perpendicular to plane is

$$I_d=\frac{MR^2}{2}=MK^2$$

$$K=R\sqrt{\frac{1}{2}} \qquad \text{......(ii)}$$

Now acceleration of anybody which is rolling on an inclined plane is

$$a=\left(\frac{g\sin\theta}{1+K^2/R^2}\right) \qquad \text{.....(iii)}$$

For same R,

$$a\propto\frac{1}{K^2}$$

$\Rightarrow$ $a_s>a_d$

So, solid sphere will reach earlier to bottom of an inclined plane than disc.

812. The ratio of the accelerations for a solid sphere (mass 'm' and radius 'R') rolling down an incline of angle 'θ' without slipping and slipping down the incline without rolling is :

(a) 5 : 7 (b) 2 : 3
(c) 2 : 5 (d) 7 : 5

AIPMT-2014
BITSAT-2010

Ans. (a) : For solid sphere rolling without slipping on inclined plane, acceleration

$$a_1=\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$$

For solid sphere slipping on inclined plane without rolling, acceleration

$$a_2=g\sin\theta$$

For solid sphere, $I=\frac{2}{5}MR^2$

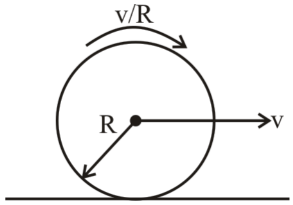
$$MK^2=\frac{2}{5}MR^2$$

$$\frac{K^2}{R^2}=\frac{2}{5}$$

Therefore, required ratio, $\frac{a_1}{a_2}=\frac{1}{\left(1+\frac{K^2}{R^2}\right)}=\frac{1}{\left(1+\frac{2}{5}\right)}=\frac{5}{7}$

i.e. $a_1 : a_2 = 5 : 7$

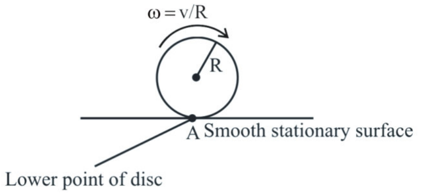
813. A disc is performing pure rolling on a smooth stationary surface with constant angular velocity as shown in figure. At any instant, for the lower most point of the disc-



(a) velocity is v, acceleration is zero
(b) velocity is zero, acceleration is zero
(c) velocity is v, acceleration is v^2/R
(d) velocity is zero, acceleration is v^2/R

BITSAT-2013

Ans. (d) :



Velocity at point A is 0 (zero) because disc performing pure rolling.

Acceleration at point A is,

@apna_pdf

We know that

$$v = R\omega$$

Or $\omega = \dfrac{v}{R}$

Angular acceleration is $(\alpha) = R\omega^2$

$$\alpha = R.\frac{v^2}{R^2} = \frac{v^2}{R}$$

So,

Acceleration at lower most point of disc is $\dfrac{v^2}{R}$.

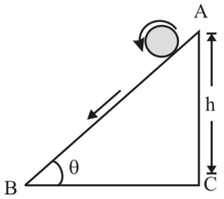
814. When a body starts to roll on an inclined plane, its potential energy is converted into

(a) translational kinetic energy only
(b) translational and rotational kinetic energies
(c) rotational kinetic energy only
(d) None of the above

CG PET- 2010

Ans. (b) : When a body starts to roll on an inclined plane, then it exhibits both translational and rotational motion. And according to conservation of energy its P.E. gets converted into translational and rotational kinetic energies.

815. If a sphere rolling on an inclined plane with velocity v without slipping, the vertical height of the incline in terms of velocity will be



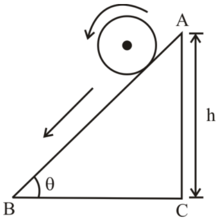
(a) $\dfrac{7v}{10g}$ (b) $\dfrac{7v^2}{10g}$

(c) $\dfrac{2v^2}{5g}$ (d) $\dfrac{3v}{5g}$

JCECE-2014

Ans. (b) : Given,

Velocity = v



Velocity of solid sphere on the bottom of inclined plane,

$$v = \sqrt{\frac{2gh}{\left(1+\frac{I}{mR^2}\right)}} \quad ....(i)$$

Where $I = \dfrac{2}{5}mR^2$

From equation (i),

$$v = \sqrt{\frac{2gh}{\left(1+\frac{I}{mR^2}\right)}} = \sqrt{\frac{2\times g\times h}{\left(1+\frac{\frac{2}{5}mR^2}{mR^2}\right)}}$$

$$v = \sqrt{\frac{2gh}{\left(1+\frac{2}{5}\right)}} = \sqrt{\frac{2gh}{\left(\frac{7}{5}\right)}}$$

$$v = \sqrt{\frac{10}{7}gh}$$

Squaring both sides,

$$v^2 = \frac{10}{7}gh$$

$$h = \frac{7v^2}{10g}$$

Hence, height will be $\dfrac{7v^2}{10g}$.

816. A solid sphere and a hollow sphere, both of the same size and same mass roll down an inclined plane. Then :

(a) solid sphere reaches the ground first
(b) hollow sphere reaches the ground first
(c) both spheres reaches the ground at the same time
(d) the time at which the spheres reach the ground cannot be specified by the given data

JCECE-2005

Ans. (a) : Given,

Mass of Solid sphere and hollow sphere = m

Radius of Solid sphere and hollow sphere = r

If sphere roll down on an inclined plane. Then, potential energy of sphere is converted into rotational kinetic energy and translational kinetic energy.

$$\text{P.E.} = (\text{K.E.})_{(\text{rotational})} + (\text{K.E.})_{(\text{Translational})}$$

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

For solid sphere,

$$I = \frac{2}{5}mr^2, \omega = \frac{v}{r}$$

So,

$$mgh = \frac{1}{2}\times\frac{2}{5}mr^2\times\frac{v^2}{r^2}+\frac{1}{2}mv^2$$

$$mgh = \frac{1}{5}mv^2+\frac{1}{2}mv^2$$

$$mgh = mv^2\left[\frac{1}{5}+\frac{1}{2}\right]$$

@apna_pdf

$$gh = \frac{7v^2}{10}$$

$$v = \sqrt{\frac{10}{7}gh}$$

For hollow sphere,

$$I = \frac{2}{3}mr^2,\ \omega = \frac{v}{r}$$

$$mgh = \frac{1}{2}\times\frac{2}{3}mr^2\times\frac{v^2}{r^2}+\frac{1}{2}mv^2$$

$$gh = \frac{5}{6}v^2$$

$$v = \sqrt{\frac{6}{5}gh}$$

Here, velocity of solid sphere > velocity of hollow sphere

Thus, solid sphere reaches the ground first.

817. Assertion: A rigid disc rolls without slipping on a fixed rough horizontal surface with uniform angular velocity. Then the acceleration of lowest point on the disc is zero.

Reason: For a rigid disc rolling without slipping on a fixed rough horizontal surface, the velocity of the lowest point on the disc is always zero.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If Assertion is incorrect but Reason is correct.

AIIMS-2013

Ans. (d) : For a disc rolling without slipping on a fixed rough horizontal surface with uniform angular velocity, the translation part of rolling produce zero acceleration at the lowest point and rotational part of rolling creates zero tangential acceleration and non-zero centripetal acceleration at the lowest point is directed in upward direction. So, the acceleration of lowest point on the disc is not zero.

Hence, Assertion is incorrect but Reason is correct.

818. Assertion: The velocity of a body at the bottom of an inclined plane of given height is more when it slides down the plane compared to when it is rolling down the same plane.

Reason: In rolling down, a body acquires both kinetic energy of translation and rotation.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

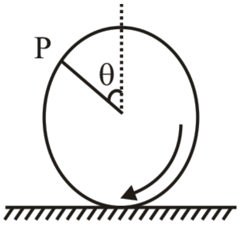
(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is incorrect but the Reason is correct.

AIIMS-2008

Ans. (b): If anybody slides, then its potential energy converted into translational kinetic energy. But when anybody rolls down the plane, some part of potential energy is converted into rotational kinetic energy because it rolls down. So, its translational kinetic energy (linear velocity) will reduce.

819. A wheel is rolling straight on ground without slipping. If the axis of the wheel has speed v, the instantaneous velocity of a point P on the rim, defined by angle θ, relative to the ground will be



(a) $v\cos\left(\frac{1}{2}\theta\right)$

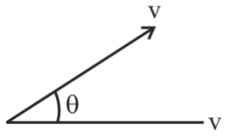
(b) $2v\cos\left(\frac{1}{2}\theta\right)$

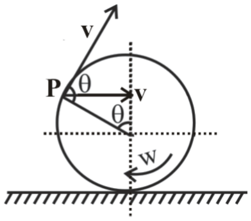
(c) $v(1 + \sin\theta)$

(d) $v(1 + \cos\theta)$

AIIMS-2014

Ans. (b) :





$$V_{net} = \sqrt{v_1^2+v_2^2+2v_1v_2\cos\theta}$$

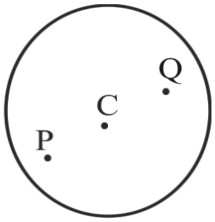
$$V_{net} = \sqrt{2v^2+2v^2\cos\theta}$$

$$V_{net} = \sqrt{2v^2(1+\cos\theta)}$$

$$V_{net} = 2v\cos\frac{\theta}{2}$$

820. A disc is rolling (without slipping) on a horizontal surface. C is its centre and Q and P are two points equidistant from C. Let V_p, V_q, V_c be the magnitude of velocities of points P, Q and C respectively, then

@apna_pdf



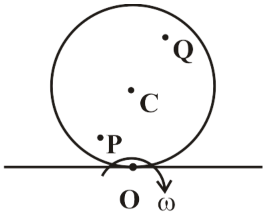
(a) $V_Q > V_C > V_P$ (b) $V_Q < V_C < V_P$

(c) $V_Q = V_P, V_C = \frac{1}{2}V_P$ (d) $V_Q = V_C = V_P$

AIIMS-2012

Ans. (a) : We know,

Velocity of any point on the disc (v) $= r\omega$



Where, r = distance of point C from O

and ω = Constant

So, $v \propto r$

About point O, motion is rotational.

Now, $OQ > OC > OP$

$\therefore \quad V_Q > V_C > V_P$

821. Which of the following is true about the angular momentum of a cylinder down a slope without slipping:

(a) its magnitude changes but the direction remains same

(b) both magnitude and direction change

(c) only the direction change

(d) neither change

AIIMS-2011

Ans. (a) : We know,

Angular momentum = mvr

The direction remains always same but the magnitude of velocity changes when the cylinder rolls. Then, angular momentum's magnitude changes but the direction remain same.

822. Two solid cylinders A and B of the same mass and same radius start rolling down a fixed inclined plane from the same height at the same time. Cylinder A has most of its mass concentrated near the surface, while B has most of its mass concentrated near the axis. Which statement is correct?

(a) Both cylinders A and B reach the ground at the same time

(b) Cylinder A has larger linear acceleration than cylinder B

(c) Both cylinders A and B reach the ground with the same translational kinetic energy

(d) Cylinder B reaches the ground with larger angular speed

BCECE-2016

Ans. (d) : We can treat cylinders A as hollow and B as solid.

For hollow cylinder A,

$$\frac{K^2}{R^2} = 1$$

Solid cylinder B,

$$\frac{K^2}{R^2} = \frac{1}{2}$$

$$\therefore \quad V_A = \sqrt{\frac{2gh}{1+1}} = \sqrt{gh}$$

$$V_B = \sqrt{\frac{2gh}{1+\frac{1}{2}}} = \sqrt{\frac{4gh}{3}}$$

$$V_B > V_A \qquad (\because V \propto \omega)$$

$$\therefore \quad \omega_B > \omega_A$$

823. A cylinder rolls up an inclined plane at an angle of 30^0. At the bottom of the inclined plane, the centre of mass of the cylinder has speed of 5 m/s. How long will take to return to the bottom?

(a) 2s (b) 3s

(c) 1.5s (d) 4s

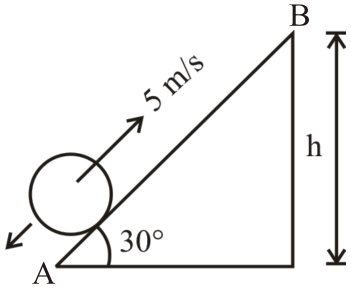
BCECE-2015

Ans. (c) : Given that,

Angle of inclination, $\theta = 30°$

Initial velocity of the solid cylinder, $v = 5\ m/s$

Height reached by the cylinder = h



From the law of conservation of energy between the initial and final states.

$$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2 = mgh$$

@apna_pdf

$$\Rightarrow \quad \frac{3}{4}mv^2 = mgh \qquad (\because\ v = r\omega)$$

$$\therefore \quad h = \frac{3v^2}{4g}$$

$$h = \frac{3\times(5)^2}{4\times 9.8} = 1.913\text{m}$$

If the distance is goes up to the inclined plane, then as

$$\sin\theta = \frac{h}{s}$$

Thus, $s = \dfrac{h}{\sin\theta}$

$$s = \frac{1.913}{\sin 30}$$

$$s = \frac{1.913}{\frac{1}{2}} = 2\times 1.913$$

$$s = 3.826\,\text{m}$$

Time taken to return to the bottom,

$$t = \sqrt{\frac{2s\left(1+\frac{K^2}{R^2}\right)}{g\sin\theta}}$$

for solid sphere

$$I = \frac{2}{5}mR^2 = mK^2$$

$$\frac{2}{5}mR^2 = mK^2$$

$$\frac{K^2}{R^2} = \frac{2}{5}$$

$$\frac{K^2}{R^2} = 0.4$$

Then,

$$t = \sqrt{\frac{2\times 3.826\times 1.4}{9.8\times\frac{1}{2}}}$$

$$t = \sqrt{\frac{10.7128}{4.9}} = \sqrt{2.1862}$$

$$t = 1.4785 \,\square\, 1.5 \text{ second}$$

824. A sphere rolls down and inclined plane without slipping. What fraction of its total energy is rotational?

(a) $\frac{2}{7}$ (b) $\frac{3}{7}$

(c) $\frac{4}{7}$ (d) $\frac{5}{7}$

BCECE-2009

Ans. (a) : Given that,
Ball is rolling without slipping,

So, $v = \omega R$

Where, v = linear velocity of the ball

ω = angular velocity of the ball

Total kinetic energy = Translational kinetic energy + Rotational kinetic energy

$$\text{Total kinetic energy} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$\text{Here, } I_{\text{sphere}} = \frac{2}{5}mR^2$$

$$\text{Total kinetic energy} = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mR^2\right)\times\left(\frac{v}{R}\right)^2$$

$$\left[\because \omega = \frac{v}{R}\right]$$

$$\text{Total kinetic energy} = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$\text{Total kinetic energy} = \frac{7}{10}mv^2$$

$$\text{Rotational K.E.} = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\times\left(\frac{2}{5}mR^2\right)\times\left(\frac{v}{R}\right)^2 = \frac{1}{5}mv^2$$

$$\therefore \quad \frac{\text{Rotational K.E}}{\text{Total K.E}} = \frac{\frac{1}{5}mv^2}{\frac{7}{10}mv^2}$$

$$\frac{\text{Rotational K.E}}{\text{Total K.E}} = \frac{2}{7}$$

825. If a uniform solid sphere and a disc of same mass and same radius rolls down on an inclined smooth plane from rest to the same distance, then the ratio of the time taken by them will be–

(a) 15 : 14 (b) $\sqrt{14} : \sqrt{15}$

(c) 14 : 15 (d) $\sqrt{15} : \sqrt{14}$

BCECE-2012

Ans. (b) : We know that,

$$t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1+\frac{k^2}{R^2}\right)} \quad (k = \text{radius of gyration})$$

for solid sphere,

$$I = \frac{2}{5}mR^2 \Rightarrow mk^2$$

$$k^2 = \frac{2}{5}R^2$$

$$\frac{k^2}{R^2} = \frac{2}{5}$$

@apna_pdf

For disc,

$$I = \frac{mR^2}{2} \Rightarrow mk^2$$

$$k^2 = \frac{R^2}{2}$$

$$\frac{k^2}{R^2} = \frac{1}{2}$$

$$\therefore \quad \frac{t_s}{t_d} = \frac{\sqrt{1+\frac{k_s^2}{R_s^2}}}{\sqrt{1+\frac{k_d^2}{R_d^2}}} \qquad \begin{bmatrix} t_s = \text{time of sphere} \\ t_d = \text{time of disc} \end{bmatrix}$$

$$\frac{t_s}{t_d} = \sqrt{\frac{1+\frac{2}{5}}{1+\frac{1}{2}}}$$

$$\frac{t_s}{t_d} = \sqrt{\frac{\frac{7}{5}}{\frac{3}{2}}} = \sqrt{\frac{14}{15}}$$

$$t_s : t_d = \sqrt{14} : \sqrt{15}$$

826. Three bodies a ring (R), a solid cylinder (C) and a solid sphere (S) having same mass and same radius roll down the inclined plane without slipping. They start from rest, if ν_R, ν_C and ν_S are velocities of respective bodies on reaching the bottom of the plane, then :

(a) $\nu_R = \nu_C = \nu_S$ (b) $\nu_R > \nu_C > \nu_S$

(c) $\nu_R < \nu_C < \nu_S$ (d) $\nu_R = \nu_C > \nu_S$

Karnataka CET-2016

Ans. (c): Given that,

Velocity of ring, R = ν_R

Velocity of cylinder, C = ν_C

Velocity of sphere, S = ν_S

Velocity of body at the bottom of incline when it rolls down the incline plane

$$v = \frac{\sqrt{2gh}}{(1 + I/mR)^2}$$

$$v = \sqrt{\frac{1}{I}}$$

$$I_R = mR^2$$

$$I_C = \frac{1}{2}mR^2$$

and $$I_S = \frac{2}{5}mR^2$$

$\therefore \quad I_R > I_C > I_S$

Or $\quad \nu_R < \nu_C < \nu_S$

827. A ring starts to roll down the inclined plane of height h without slipping. The velocity with which it reaches the ground is

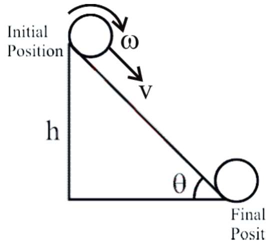
(a) $\sqrt{\frac{10gh}{7}}$ (b) $\sqrt{\frac{4gh}{7}}$

(c) $\sqrt{\frac{4gh}{3}}$ (d) $\sqrt{2gh}$

(e) $\sqrt{gh}$

Kerala CEE - 2011

Ans. (e) :



For ring, moment of inertia, I = mr^2 and v = rω

Potential energy = Rotational K.E. + Translational K.E.

$$mgh = (K.E.)_R + (K.E.)_T$$

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

$$mgh = \frac{1}{2}mr^2\frac{v^2}{r^2} + \frac{1}{2}mv^2$$

$$gh = \frac{1}{2}v^2 + \frac{1}{2}v^2$$

$$gh = v^2$$

$$v = \sqrt{gh}$$

828. A solid sphere of mass 2 kg rolls on a smooth horizontal surface at 10 m/s and then rolls up a smooth 30° incline. The maximum height reached by the sphere is ($g=9.8m/s^2$)

(a) 10 m (b) 4.9 m

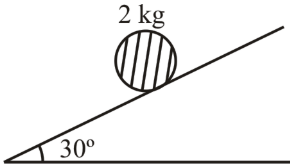
(c) 14.2 m (d) 7.1 m

CG PET- 2015

Ans. (d) : Given, Mass (m) = 2 kg

Angle of inclination = 30°

Velocity (v) = 10 m/s



Now, using the energy conservation on rolling sphere–

$$(K.E)_T + (K.E)_R = P.E$$

@apna_pdf

Where, $(K.E)_T$ = Translational kinetic energy

$(K.E)_R$ = Rotational kinetic energy

P.E = Potential energy

$$\therefore \quad \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{2}.\frac{2}{5}mr^2\omega^2 = mgh \quad \left(\because I = \frac{2}{5}mr^2\right)$$

$$\frac{v^2}{2} + \frac{v^2}{5} = gh \quad (\because v = r\omega)$$

$$\frac{5v^2 + 2v^2}{9.8\times10} = h$$

$$h = \frac{7\times10\times10}{9.8\times10}$$

h = 7.1 m

829. The acceleration of the centre of mass of a uniform solid disc rolling down an inclined plane of angle α is

(a) g sin α (b) 2/3 g sinα

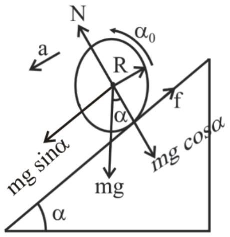
(c) 1/2 g sinα (d) 1/3 g sinα

UPSEE - 2008

Ans. (b) : Let a = linear acceleration of the solid disc.

α_0 = angular acceleration of the solid disc

m = mass of solid disc



From figure,

$$ma = mg\sin\alpha - f \quad \text{….. (i)}$$

But $\tau_{net} = I\alpha_0$

$$f\times R = \frac{mR^2}{2}\alpha_0$$

$$f = \frac{mR}{2}\alpha_0$$

$$f = \frac{ma}{2} \quad (\because \ a = R\alpha_0)$$

Now, from equation (i), we get

$$ma = mg\sin\alpha - \frac{ma}{2}$$

$$\frac{3}{2}ma = mg\sin\alpha$$

$$a = \frac{2}{3}g\sin\alpha$$

830. A solid sphere of mass 1 kg, radius 10 cm rolls down an inclined plane of height 7m. The velocity of its centre as it reaches the ground level is

(a) 7m/s (b) 10m/s

(c) 15m/s (d) 20m/s

AMU-2010

Ans. (b) : Given that,

Mass (m) = 1 kg

Radius (R) = 10 cm

Height (h) = 7 m

We know that,

$$v = \sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}} \quad \text{where, K is Radius of gyration}$$

For a solid sphere,

$$\frac{K^2}{R^2} = \frac{2}{5}$$

So, $$v = \sqrt{\frac{2\times10\times7}{\left(1+\frac{2}{5}\right)}}$$

$$v = \sqrt{\frac{140}{\frac{7}{5}}}$$

$$v = \sqrt{140\times\frac{5}{7}}$$

$$v = \sqrt{100}$$

v = 10 m/s

831. At any instant, a rolling body may be considered to be in pure rotation about an axis through the point of contact. This axis is translating forward with speed

(a) equal to centre of mass

(b) zero

(c) twice of centre of mass

(d) None of the above

AIPMT- 1989

Ans. (a) : The instantaneous axis of rotation is always below the centre of mass. This is only possible when point of contact moves with a velocity equal to centre of mass.

832. A thin uniform circular ring is rolling down an inclined plane of inclination 30° without slipping. Its linear acceleration along the inclined plane will be

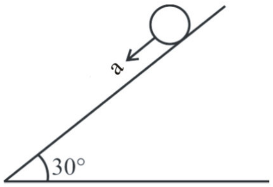
@apna_pdf

(a) $\frac{g}{2}$ (b) $\frac{g}{3}$

(c) $\frac{g}{4}$ (d) $\frac{2g}{3}$

AIPMT- 1994

Ans. (c) :



We know that, acceleration on inclined plane in rolling motion–

$$a = \frac{g\sin\theta}{1+\frac{K^2}{R^2}}$$

For ring, $\frac{K^2}{R^2} = 1$

$$a = \frac{g\sin 30°}{1+1}$$

$$a = \frac{g\times\frac{1}{2}}{2} \qquad \left[\because \sin 30° = \frac{1}{2}\right]$$

$$a = \frac{g}{4}$$

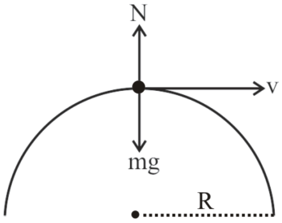
833. A very small particle rests on the top of a hemisphere of radius 20 cm. The smallest horizontal velocity to be given to it, if it is to leave the hemisphere without sliding down its surface, taking g = 9.8 ms^{-2} is

(a) 1.4 ms^{-1} (b) 2.4 ms^{-1}

(c) 0.4 ms^{-1} (d) 0.7 ms^{-1}

EAMCET-1993

Ans. (a) :



Given,

R = 20 cm = 0.2 m

g = 9.8 m/s^2

According to question,

When particle is rest on the top of hemisphere–

$$mg - N = \frac{mv^2}{R}$$

If particle leave the hemisphere without sliding then,

$$N = 0$$

$$\therefore \quad mg = \frac{mv^2}{R}$$

$$v = \sqrt{Rg}$$

$$v = \sqrt{0.2\times 9.8} \text{ m/s}$$

$$v = \sqrt{1.96}$$

$$v = 1.4 \text{ m/s}$$

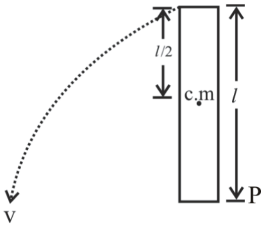
834. A rod of length *l* is held vertically stationary with its lower end located at a position P on the horizontal plane. When the rod is released to topple about P, the velocity of the upper end of the rod with which it hits the ground is

(a) $\sqrt{\frac{g}{l}}$ (b) $\sqrt{3gl}$

(c) $3\sqrt{\frac{g}{l}}$ (d) $\sqrt{\frac{3g}{l}}$

AP EAMCET(Medical)-2009

Ans. (b) :



The rod topples about point P.

So, MOI of rod (I) = $\frac{Ml^2}{3}$

By law of conservation of energy-

Loss in P.E = gain in K.E

$$mg\frac{l}{2} = \frac{1}{2}I\omega^2$$

$$mg\frac{l}{2} = \frac{1}{2}\frac{ml^2}{3}\times\omega^2 \qquad \left[\because I = \frac{ml^2}{3}\right]$$

$$\omega = \sqrt{\frac{3g}{l}}$$

For rotation about point P–

$$\therefore \quad v = \omega l$$

So, $$v = \sqrt{\frac{3g}{l}}\times l$$

$$v = \sqrt{3gl}$$